Biological Evaluation

the Approval of Virginia's Water Quality Standards Title 9 VACS 25-260 Water Quality Standards Regulations Adoption of Ammonia and Cadmium

by U.S. Environmental Protection Agency for the U.S. National Marine Fisheries Service

10-15-2018

Cheryl Atkinson
10/15/2018 EPA Region III WQS Coordinator

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Executive Summary

This biological evaluation (BE) assesses the potential effects which may occur to federally listed threatened and endangered marine species and anadromous fish under the jurisdiction of the U.S. National Marine Fisheries Service (NMFS). The specific focus of this evaluation is the U.S. Environmental Protection Agency (EPA), Clean Water Act (CWA) approval of Virginia's proposed updates to its aquatic life criteria to be consistent with the EPA's recommended criteria for ammonia and cadmium. These criteria consider the best available science, including local and regional information, as well as applicable EPA policies, guidance, and legal requirements, to protect aquatic life including listed species. EPA finds that our proposed approval of Virginia's acute and chronic ammonia and cadmium criteria are Not Likely to Adversely Affect (NLAA) aquatic listed species through direct and indirect effects and will not adversely modify Atlantic sturgeon critical habitat.

EPA views the ammonia and cadmium criteria revisions as insignificant and/or discountable to the conservation and protection of aquatic life, including listed species and their food sources in Virginia. The revisions are expected to aid in the conservation role of critical habitat. The listed sturgeon, turtles, and whales occurring in Virginia freshwaters and/or estuarine/marine waters are not sensitive to acute and chronic freshwater ammonia and cadmium exposures at the respective criteria magnitudes under conservative exposure conditions.

Introduction

Description of the Proposed Action

Endangered Species Act (ESA)

Federally protected species are listed as endangered or threatened under the Endangered Species Act of 1973, as amended, 16 U.S.C. Section 1536, and its implementing regulations, 50 C.F.R. Part 402. Section 7(a) of the ESA grants authority to, and imposes requirements upon, federal agencies regarding endangered or threatened species of fish, wildlife, or plants ("listed species") and habitat of such species that have been designated as critical ("critical habitat"). The ESA requires every federal agency, in consultation with the Secretary of Interior, to ensure that any action it authorizes, funds, or carries out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The United States Fish and Wildlife Service (USFWS) administers Section 7 consultations for freshwater species, while the United States National Marine Fisheries Service (NMFS) administers Section 7 consultations for marine species and anadromous fish. This BE representing an effort by the EPA to informally consult with NMFS regarding the EPA approval action of Virginia WQS, which may affect listed species sand their critical habitat.

EPA 's WQS Program

A WQS defines the water quality goals for a waterbody by designating the use or uses of the water, by setting criteria necessary to protect the uses, and by preventing or limiting degradation of water quality through anti-degradation provisions. Under Section 303(c) of the CWA and 40 CFR Part 131, states and authorized tribes (state) have the primary responsibility to develop and adopt WQS to protect their waters. Also under the CWA Section 303(c) and 40 CFR Part 131, the EPA is required to review and either approve or disapprove new and revised state WQS.

New and revised state WQS are not considered effective for CWA purposes until approved by the EPA under CWA Section 303(c).

Unlike other EPA actions that may introduce a pollutant into the environment, approval of a WQS limits the allowable level of a pollutant that, in the absence of the standard, would be unlimited. As an analytical simplification, this BE protocol considers whether the criterion at issue is sufficiently stringent so that listed species would be protected. This federal action neither authorizes the introduction of a pollutant into the environment nor represents a plan to authorize any such introduction so long as the criterion is not exceeded.

Virginia's Ammonia and Cadmium Aquatic Life Criteria Revisions

On September 18, 2017, the Virginia Department of Environmental Quality (VADEQ) announced for public review and comment its proposed amendments to its cadmium and ammonia aquatic life water quality criteria. The comment period ended December 8, 2017. Virginia is expected to respond to public comments and publish revised cadmium and ammonia aquatic life water quality criteria within the coming year. Pursuant to the EPA's authority outlined in CWA Section 303(c) and 40 CFR Part 131, the EPA must review and approve the final new or revised cadmium and ammonia aquatic life water quality criteria. If the revisions to the aquatic life criteria are consistent with the revisions submitted to the EPA during the public comment period and evaluated below, the EPA requests concurrence from the Services to confirm that the revisions are not likely to adversely affect listed species or their critical habitat. If revisions to the aquatic life criteria significantly differ from what was published during the public comment period and evaluated below, the EPA will resubmit another BE for informal consultation.

Virginia's amendment to its cadmium criteria for the protection of fresh and saltwater aquatic life is based on the EPA's national recommended water quality criteria issued in 2016. The EPA updated national recommended cadmium criteria account for many new laboratory toxicity tests for cadmium. In addition, the effect of total hardness on cadmium toxicity was also revised using the newly acquired data, including toxicity data for 75 new species and 49 new genera.

Virginia has proposed to amend its freshwater ammonia aquatic life criteria to be consistent with the EPA's 2013 nationally recommended freshwater ammonia aquatic life criteria, issued by the EPA 2013. Like Virginia's current criteria, the proposed criteria are calculated as a function of temperature and pH and account for the presence or absence of trout and early life stages of fish. The recalculated ammonia criteria now incorporate toxicity data for freshwater mussels in the family unionidae, which are the most sensitive organisms in the recalculation data base. The new criteria are about twice as stringent as the existing criteria primarily because more recent toxicity data show that mussels and snails (including endangered species) are very sensitive to ammonia and the current ammonia criteria do not provide sufficient protection for these species. Site specific options to calculate criteria omitting mussel toxicity data are proposed to be used in waters where a demonstration has been made that mussels are absent; however, Virginia's consultation with FWS and the Virginia Department of Game and Inland Fisheries indicate freshwater mussels should be considered ubiquitous in Virginia and likely to be present in any perennial waterbody.

The federal action being evaluated under ESA, Section 7 is the approval by the EPA of the new and revised provisions regarding Virginia's proposed updates to its cadmium and ammonia aquatic life water quality criteria. These criteria are adopted and implemented to maintain and protect the waters of Virginia, and they provide for the propagation and protection of aquatically-dependent listed species. The WQS revisions discussed here consider the best available science, including local and regional information, as well as the applicable EPA policies, guidance, and legal requirements, to protect aquatic life.

EPA 's 304(a) Nationally Recommended Criteria

Section 304(a) of the CWA authorizes the EPA to develop and revise recommended criteria for specific pollutants reflecting the latest scientific knowledge. These criteria documents provide justification for water quality criteria, including comprehensive literature reviews and toxicological analyses. In 2013, EPA published revised recommended criteria for ammonia and in 2016, EPA published revised recommended criteria for cadmium, both of which are for the protection of aquatic life. The updated criteria are reflective of new toxicity data, which were unavailable during past updates. The criteria are intended to be protective of aquatic life, including federally-listed endangered and threatened species. VA proposed to adopt EPA's recommended criteria for ammonia and cadmium; therefore, EPA's criteria documents are used throughout this BE to evaluate the potential effects of VA's WQS revisions on listed species

The Ammonia Criteria

Ammonia is one of several forms of nitrogen that exist in aquatic environments and is considered one of the most important pollutants not only because of its highly toxic nature, but also its ubiquity in surface water systems (Russo 1985). The agricultural industry uses approximately 90% of the U.S. annual domestic ammonia production for fertilizer (USGS 2004). Ammonia also has numerous industrial applications, including use in metal finishing and treating applications (e.g., nitriding; Appl 1999), in the chemical industry for the production of pharmaceuticals (Karolyi 1968) and dyes (Appl 1999), in the petroleum industry for processing of crude oil and in corrosion protection, and in the mining industry for metals extraction (U.S. EPA 2004). Natural sources of ammonia include the decomposition or breakdown of organic waste matter, gas exchange with the atmosphere, forest fires, animal waste, the discharge of ammonia by aquatic biota, and nitrogen fixation processes (Environment Canada 1997; Geadah 1985).

Ammonia can enter the aquatic environment via anthropogenic sources, such as municipal effluent discharges and agricultural runoff, and natural sources, such as nitrogen fixation and the excretion of nitrogenous wastes from animals. In 2011, there were approximately 4.7 million pounds (lbs.) of ammonia documented as discharged from all reporting industries to surface waters (U.S. EPA 2011).

Ammonia is unique among regulated pollutants because it is a toxicant that organisms have developed various strategies to excrete. When ammonia is present in water at high enough levels, it is difficult for aquatic organisms to sufficiently excrete the toxicant, leading to toxic buildup in internal tissues and blood, and potentially death. The toxic action of ammonia on aquatic animals, particularly in sensitive fish, may be due to one or more of the following causes:
(1) proliferation in gill tissues, increased ventilation rates and damage to the gill epithelium (Lang et al. 1987); (2) reduction in blood oxygen-carrying capacity due to progressive acidosis

(Russo 1985); (3) uncoupling oxidative phosphorylation causing inhibition of production and depletion of adenosine triphosphate in the brain (Camargo and Alonso 2006); (4) and the disruption of osmoregulatory and circulatory activity disrupting normal metabolic functioning of the liver and kidneys (Arillo et. al.1981; Tomasso et al. 1980).

Among invertebrates, studies testing ammonia toxicity to bivalves, and particularly studies with freshwater mussels in the family Unionidae, have demonstrated their sensitivity to ammonia (Augspurger et al. 2003; Wang et al. 2007a, b; Wang et al. 2008). Toxic effects of unionized ammonia to both freshwater and marine bivalves include reduced opening of valves for respiration and feeding (Epifanio and Srna 1975); impaired secretion of the byssus, or anchoring threads in bivalves (Reddy and Menon 1979); reduced ciliary action in bivalves (U.S. EPA 1985); depletion of lipid and carbohydrate stores leading to metabolic alteration (Chetty and Indira 1995) as well as mortality (Goudreau et al. 1993). These negative physiological effects may lead to reductions in feeding, fecundity, and survivorship, resulting in decreased bivalve populations (Alonso and Camargo 2004; Constable et al. 2003).

In 2013, EPA revised and published recommended aquatic life criteria for ammonia in freshwaters based on EPA's latest scientific studies and toxicity data from over 69 aquatic genera including fish, invertebrate, and amphibian species, of which 12 are federally-listed as endangered, threatened, or a species of concern (U.S.EPA 2013). The 2013 document, which represents a revision of the 1999 recommended aquatic life criteria for ammonia, incorporates additional toxicity data for several sensitive freshwater mussel species. EPA's research suggests that freshwater mussels and gill-breathing snails are generally more sensitive to ammonia as compared to other aquatic life, such as fish and other invertebrates. The acute ammonia criterion is pH and temperature dependent, with invertebrates being more sensitive at higher temperatures (e.g., > 16 ^{o}c) and fishes in the genus Oncorhynchus being the most sensitive organisms at lower temperatures. The chronic ammonia criterion is also pH and temperature dependent, but does not differ based on the presence of fishes in the genus Oncorhynchus. VA revised it criteria to be consistent with EPA's recommended criteria, which represent the latest scientific knowledge regarding ammonia toxicity on aquatic life.

The ammonia criteria are defined by a magnitude, duration, and frequency. The magnitude is the maximum pollutant concentration allowable, the duration is the time period in which the magnitude is averaged, and the frequency is the allowable number of times the pollutant concentrations can exceed the magnitude during a recurrence interval. It is important to note that analysis of the criteria magnitude has been the primary focus of previous BEs. Critical aspects of the criteria, including the duration and frequency, provide a high level of additional conservatism and protectiveness to the criteria overall. The magnitude of the ammonia criteria is represented as acute and chronic concentrations and are expressed as functions of temperature and pH of the receiving waterbody. The criteria document describes the relationship between ammonia and these water quality factors. For example, at a pH of 7 and temperature of 20^{0}C, the 2013 acute criterion is 17 mg TAN/L and the chronic criterion is 1.9 mg TAN/L. In addition, the proposed criteria include a duration requirement that the highest four-day average within the same 30-day period used to determine compliance with the chronic criterion shall not exceed 2.5 times the chronic criterion and a one-hour average may not exceed the acute criterion. A frequency requirement states that the criteria are not to be exceeded more than once every three years.

Acute measures of effect used for aquatic organisms to develop the ammonia criteria are the lethal concentration (LC) 50 and effective concentration (EC) 50. LC is the concentration of a chemical that is estimated to kill the noted percentage of the test organisms. EC is the concentration of a chemical that is estimated to affect growth, survival, and/or reproduction in the noted percentage of the test organisms. These concentrations are then normalized to a pH of 7.0 (for all organisms) and temperature of 20^0C (for invertebrates). The pH and temperature conditions to which these data are normalized were deemed to be generally representative of ambient surface water. These normalized values were then used to rank genus mean acute values (GMAV) calculated from combined species mean acute values (SMAVs) within each genus. A final acute value (FAV) is then determined by regression analysis using a log-triangular fit based on the four most sensitive GMAVs in the data set to interpolate or extrapolate (as appropriate) to the 5th percentile of the distribution represented by the tested genera. If there are 59 or more GMAVs, as is the case with ammonia, the four GMAVs closest to the 5th percentile of the distribution are used to calculate the FAV. Finally, the FAV is divided by two to calculate the acute criterion as per the 1985 guidelines (Stephan et al. 1985). The FAV divided by two approach was developed to estimate minimal effect levels, those which approximate control mortality limits, and is based on the analysis of 219 acute toxicity tests for a range of chemicals, as described in the Federal Register on May 18, 1978 (43 FR 21506-18). Ammonia acute toxicity data were available for 44 species of fish, 52 invertebrates, and four amphibians, including 12 species federally-listed as endangered, threatened, or species of concern.

Chronic measures of effect used for aquatic organisms to develop the ammonia criteria are EC20, no-observed-effect-concentrations (NOEC), lowest-observed-effect-concentrations (LOEC), and maximum acceptable toxicant concentration (MATC). EC20 values were used to estimate a low level of effect observed in chronic datasets that are available for ammonia (see U.S. EPA 1999). The NOEC is the highest test concentration at which none of the observed effects are statistically different from the control. The LOEC is the lowest test concentration at which observed effects are found to be statistically different from the control. The MATC is the calculated geometric mean of the NOEC and LOEC. All chronic data in individual studies were analyzed using regression analysis to demonstrate the presence of a concentration-effect relationship within the test. For those studies that demonstrated a concentration-effect relationship, EPA used regression analysis to estimate the EC20. These values were then used to rank genus mean chronic values (GMCV) calculated from combined species mean chronic values (SMCVs) within each genus. EPA calculated the chronic criterion as the final chronic value (FCV) based on the fifth percentile of the GMCVs. The four lowest values were used to calculate the FCV because values for fewer than 59 genera exist. Ammonia chronic toxicity data are available for 21 species of freshwater organisms: ten invertebrate species (mussels, clam, snail, cladocerans, daphnid, and insect) and 1 1 fish species, including three Federally-listed salmonids.

The acute and chronic ammonia toxicity data used to develop the acute and chronic criteria for ammonia in freshwater were collected via literature searches of EPA' s ECOTOX database, EPA's Ambient Aquatic Life Water Quality Criteria for Ammonia (U.S. EPA 1985, 1998, 1999), data provided by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (collectively known as the Services), and EPA regional and field offices. All available, reliable acute and chronic toxicity values published since 1985 were incorporated into the appropriate ammonia tables and used to recalculate the acute and the chronic criterion, as outlined in detail in the 1985 Guidelines. The most recent literature search covered the period from 1985 through October 2012.

The Cadmium Criteria

Cadmium is a relatively rare, naturally occurring metal found in mineral deposits and distributed widely at low concentrations in the environment. Cadmium is used by industry to manufacture batteries, pigments, plastic stabilizers, metal coatings, alloys, electronics, and nanoparticles for use in solar cells and color displays. These anthropogenic sources are responsible for over 90 percent of the cadmium found in surface waters. Upon entering aquatic environments, majority of cadmium becomes strongly adsorbed to sediments, removed from the water column, and often not bioavailable to organisms.

Cadmium is a non-essential metal with no biological function in aquatic animals (Eisler 1985; Lee et al. 1995; McGeer et al. 2012; Price and Morel 1990; Shanker 2008). In one study comparing the acute toxicity of all 63 atomically stable heavy metals in the periodic table, cadmium was found to be the most acutely toxic metal to the amphipod, Hyalella azteca, based on the results of seven-day acute aquatic toxicity tests (Borgmann et al. 2005). In addition to acute toxicity, cadmium is a known teratogen and carcinogen, is a probable mutagen and is known to induce a variety of other short- and long-term adverse physiological effects in fish and wildlife at both the cellular and whole-animal level (Eisler 1985; Okocha and Adedeji 2011). Chronic exposure leads to adverse effects on growth, reproduction, immune and endocrine systems, development, and behavior in aquatic organisms (McGeer et al. 2012). Other toxic effects include histopathologies of the gill, liver and kidney in fish, renal tubular damage, alterations of free radical production and the antioxidant defense system, immunosuppression, and structural effects on invertebrate gills (Giari et al. 2007; Jarup et al. 1998; McGeer et al. 2011; Okocha and Adedeji 2011; Shanker 2008). Cadmium can bioaccumulate in aquatic organisms, with total uptake depending on the environmental cadmium concentration, exposure route and the duration of exposure (Annabi et al. 2013; Francis et al. 2004; McGeer et al. 2000; Roméo et al. 1999).

Toxic effects are thought to result from the free ionic form of cadmium (Goyer et al. 1989), which causes acute and chronic toxicity in aquatic organisms primarily by disrupting calcium homeostasis and causing oxidative damage. In freshwater fish, cadmium competes with calcium at high affinity binding sites in the gill membrane and blocks the uptake of calcium from water by interfering with ion uptake in specialized calcium channels that are located in the mitochondria-rich chloride cells (Carroll et al. 1979; Evans 1987; McGeer et al. 2012; Morel and Hering 1993; Pagenkopf 1983; Tan and Wang 2009). The combined effect of competition for the binding sites and blockage of calcium uptake on the gill membrane results in acute hypocalcaemia in freshwater fish, which is characterized by cadmium accumulation in tissues as well as decreased calcium concentrations in plasma (McGeer et al. 2011; Roch and Maly 1979; Wood et al. 1997).

In 2016, EPA revised and published recommended aquatic life criteria for cadmium (U.S. EPA, 2016). The revised criteria represent an update to EPA's 2001 cadmium criteria and include additional aquatic life toxicity tests on 75 new species, nine of which are federally-listed as endangered or threatened, and 49 new genera published since 2001. DC adopted EPA's recommended criteria, which represent the latest scientific knowledge regarding cadmium toxicity on aquatic life.

Like ammonia, the cadmium criteria are defined by a magnitude, duration, and frequency. The magnitude of the cadmium criteria is represented as acute and chronic concentrations and are expressed as a function of hardness of the receiving waterbody. The criteria document describes the relationship between cadmium and hardness. For example, at a total hardness of 100 mg/L as CaC03, the acute criterion is 1.8 gg/L and the chronic criterion is 0.72 gg/L. In addition, the proposed criteria include a duration requirement that the acute criterion not be exceeded over a one-hour average and a chronic criterion not be exceeded over a four-day average. A frequency requirement states that the criteria are not to be exceeded more than once every three years.
The acute measures of effect used for aquatic organisms to develop the cadmium criteria are the LC50, EC50, and Inhibitory concentration (IC) 50. IC is the concentration of a chemical that is estimated to inhibit some biological process (e.g., growth) in the noted percentage of the test organisms. These concentrations are then normalized with a hardness of 100 mg/L CaC03. The hardness conditions to which these data are normalized were deemed to be generally representative of ambient surface water. These normalized values were then used to rank genus mean acute values (GMAV) calculated from combined species mean acute values (SMAVs) within each genus. A final acute value (FAV) is then determined by regression analysis using a log-triangular fit based on the four most sensitive GMAVs in the data set to interpolate or extrapolate (as appropriate) to the 5th percentile of the distribution represented by the tested genera. As per the 1985 guidelines and because the SMAV for the commercially and recreationally important rainbow trout was lower than the calculated FAV, the final FAV was lowered to protect the species. Finally, the FAV is divided by two to calculate the acute criterion. Cadmium acute toxicity data are available for 101 species and 75 genera of invertebrates, fish, and amphibians, of which nine species are federally-listed as endangered, threatened, or a species of concern.

The chronic measures of effect used for aquatic organisms to develop the cadmium criteria are the EC20, NOEC, and LOEC. EPA selected an EC20 to estimate a low level of effect that would be statistically different from control effects, but not severe enough to cause chronic effects at the population level (see U.S. EPA 1999a). Reported NOECs and LOECs were only used for the derivation of chronic criterion when an EC20 could not be calculated for the genus. When LOECs and NOECs are used, a MATC is calculated. These concentrations were normalized to a hardness of 100 mg/L CaC03. The values were then used to rank GMCVs calculated from combined SMCVs within each genus. EPA calculated the chronic criterion as the FCV based on the fifth percentile of the GMCVs. The four lowest values were used to calculate the FCV because values for fewer than 59 genera exist. Cadmium chronic toxicity data are available for 27 species representing 20 genera, of which four species are federally-listed as endangered, threatened, or a species of concern.

During CWA Section 304(a) criteria development, EPA reviews and considers all relevant toxicity test data. Information available for all relevant species and genera are reviewed to identify: 1) data from acceptable tests that meet data quality standards; and 2) whether the acceptable data meet the minimum data requirements (MDRs) as outlined in EPA's 1985

Guidelines (Stephan et al. 1985; U.S. EPA 1986). The taxa represented by the different MDR groups represent taxa with different ecological, trophic, taxonomic and functional characteristics in aquatic ecosystems, and are intended to be a representative subset of the diversity with a typical aquatic community.

Action Area

The EPA's proposed approval of the Virginia revised ammonia and cadmium criteria applies to all waters of the United States (within the Commonwealth of Virginia) under federal jurisdiction. Jurisdiction over non-navigable, isolated, and intrastate waters would likely have to be determined on a case-by-case basis. The area evaluated for action is the surface waters of the Commonwealth. Waters of the Commonwealth are defined in section Title 62.1 of the Waters of the State, Ports and Harbors Law as "water includes all waters, on the surface and under the ground, wholly or partially within or bordering the Commonwealth or within its jurisdiction and which affect the public welfare."

According to ESA. the action area is defined as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR Part 402.02). This includes the project's footprint as well as the area beyond it that may experience direct or indirect effects that would not occur but for the action. For NMFS listed species, applicable waters include coastal waters of the Atlantic Ocean, the Chesapeake Bay, and the Potomac, Rappahannock, York, and James Rivers, inclusive of all tributaries. These water bodies represent the extent of where effects of the action on listed species may occur.

Listed Species and Critical Habitat within the Action Area

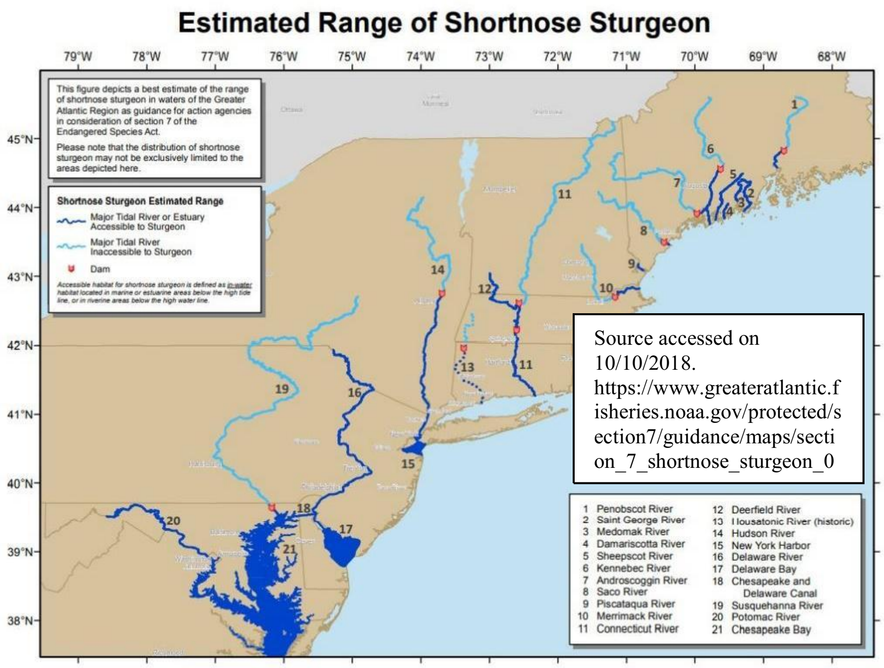
Species that have more than a limited exposure to water are considered either aquatic or aquatic-dependent and, as such, are subject to consultation. The EPA obtained a current list of species believed to or known to occur in Virginia from the NOAA Fisheries, Greater Atlantic Region website to determine if any listed, proposed or candidate species may be present in the action area. This list is included as an attachment to this BE. EPA has determined that based on the overlapping action area with species ranges, the following species and associated critical habitat may be affected by EPA's approval of VA's WQS revisions.

TABLE: VA Species of Interest for ESA Consultation w/ NMFS

Jurisdiction	Category	Class	Species	Applicable Aquatic Life Criteria for this action
NMF	Aquatic	Fish	Atlantic sturgeon Acipenser oxyrinchus	Freshwater & Estuarine/Marine
NMF	Aquatic	Fish	Sturgeon, shortnose Acipenser revirostrum	Freshwater & Estuarine/Marine
NMF	Aquatic	Sea Turtle	Green Sea Turtle Chelonia mydas	Estuarine/Marine
NMF	Aquatic	Sea Turtle	Kemp's Ridley Sea Turtle Lepidochelys kempii	Estuarine/Marine
NMF	Aquatic	Sea Turtle	Leatherback Sea Turtle Dermochelys coriacea	Estuarine/Marine
NMF	Aquatic	Sea Turtle	Loggerhead Sea Turtle Caretta caretta	Estuarine/Marine

TABLE: VA Species of Interest for ESA Consultation w/ NMFS				
Jurisdiction	**Category**	**Class**	**Species**	**Applicable Aquatic Life Criteria for this action**
NMF	Aquatic	Whales Mammals	North Atlantic right whale Eubalaena glacialis	Estuarine/Marine
NMF	Aquatic	Whales Mammals	Fin whale Balaenoptera physalus	Estuarine/Marine

Shortnose Sturgeon



Year listed: 1967 Status: Endangered. Shortnose sturgeon are a large long lived benthic species. They are anadromous, living mainly in slower moving riveriene waters or nearshore marine waters, and migrating periodically into faster moving fresh waters areas to spawn, Shortnose sturgeon mainly occupy the deep channel sections of large rivers, but will forage where food is accessible. They feed on a verity of benthic and epibenthic invertebrates including mollusks, crustations (amphipods, chironomids, isopods), and oligochate worms in soft-sediment habit. Shortnose sturgeon are opportunitc foragers, and will forage where appropriate prey items are located.

General distribution: (Source Shortnose Sturgeon GARFO Master ESA Species Table dated 9/17/18, found at https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/garfo_master_esa_species_table_-_shortnose_sturgeon_09172018.pdf. accessed on 10/10/2018)

Atlantic Ocean waters and associated bays, estuaries, and coastal river systems from Minas Basin, Nova Scotia, Canada, to the St. Johns River, Florida; only adults occur in marine waters, with some adults making coastal migrations between river systems (e.g., Penobscot River to Merrimack River via the Gulf of Maine; Merrimack River to Connecticut River via the Gulf of Maine and Long Island Sound; Connecticut River to Hudson River via Long Island Sound and the East River); typically, distribution in rivers and inshore bays occurs from the estuary or river mouth up to the first impassible barrier (e.g., a dam or falls); comprehensive information on species biology and distribution is available in the Shortnose Sturgeon Status Review Team's Biological Assessment (SSSRT 2010; available at: http://www.nmfs.noaa.gov/pr/pdfs/species/shortnosesturgeon_biological_assessment2010.pdf) Critical habitat in GAR: None

Waterbodies within the Action Areas: The shortnose sturgeon (Acipenser brevirostrum), which has been federally listed as endangered since March 1 1, 1967, is one of the species under NMFS's jurisdiction that may occur within the action area in Virginia. Shortnose sturgeon have been rarely documented south of the Maryland-Virginia border and into areas of southern Chesapeake Bay. Spells (1998), Skjeveland et al. (2000), and Welsh et al. (2002) all reported only one capture each of adult shortnose sturgeon in the Rappahannock River. In the James River, one adult shortnose sturgeon was captured at river kilometer (RKM) 48 in March 2016 (Balazik 2017), and one gravid female shortnose sturgeon was captured in the James River just downstream of the Hog Island discharge (near RKM 48) in February 2018 (Balazik, pers. comm.). These captures of adults are the only records of shortnose sturgeon in the southwestern portion of Chesapeake Bay, at this time.

Body of Water (State)	Distribution/Range in Watershed	Life Stages Present	Use of the Watershed	References
Chesapeake Bay (MD/VA)	Maryland and Virginia waters of mainstem bay and tidal tributaries including those specifically listed below.	adults documented; other life stage presence unknown	**Foraging, Resting, and Overwintering** -Assumed to occur in areas with suitable forage [1][2]	[1] SSSRT 2010; [2] Balazik 2017
Potomac River (MD/VA)	Up to Little Falls Dam (RKM 189)	adults documented; other life stages assumed but unknown	**Spawning** - Historically occurred; current spawning not documented but assumed based on presence of pre-spawning females and suitable habitat at RKM 185-187[1] **Rearing** - Eggs expected at RKM 185-187, larvae would be present downstream in freshwater [1] **Foraging** - Mainly in the deepwater channel from RKM 63-141[1][2] **Overwintering** - Near Mattawoman Creek; saltwater/freshwater reach near Craney Island [1][2] (RKM 63-141)	[1] Kynard et al. 2007; [2] Kynard et al. 2009
Rappahannock River (VA)	Range not confirmed, but they have been documented in this river (likely throughout the entire river)	adults	**Foraging** - Potentially occurs where suitable forage is present; one was captured in May 1998[1]	[1] Spells 1998
York River (VA)	Range unknown (potentially throughout the river and tributaries)	adults	**Foraging** -Potentially occurs where suitable forage is present [1]	[1] Balazik, pers. comm., June 7, 2018
James River (VA)	Range not confirmed, but likely up to Boshers Dam (RKM 182.3)	adults	**Foraging/Spawning** - Foraging potentially occurs where suitable forage is present; a sturgeon, possibly from the Potomac or Delaware River, was captured on March 13, 2016, at RKM 48[1]; on February 2018, a second sturgeon (a confirmed gravid female) was captured near RKM 48[2] (genetics results not yet available); spawning area unknown; the salinity at RKM 48 is usually low (brackish).	[1] Balazik 2017; [2] Balazik, pers. comm., February 10, 2018

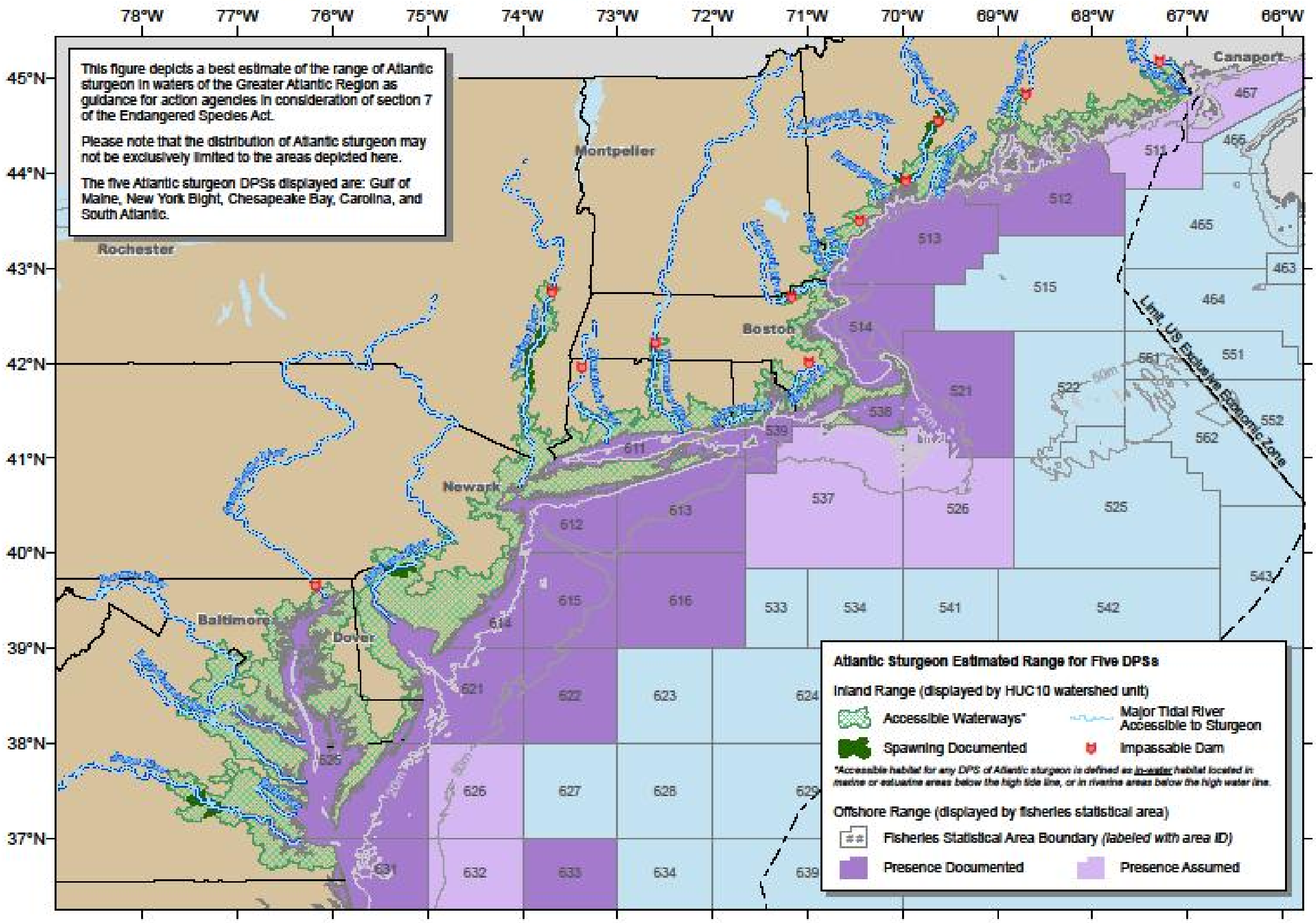
In summary, NMFS expect adult shortnose sturgeon to utilize all waters of the action area in VA. These fish would be migrating, foraging, resting, and potentially spawning only in the upper portions of the Potomac River, where early life stages (ELS) (eggs and larvaes) as well as juveniles may also be present within this portion of the action area.

Atlantic Sturgeon

Year listed: 2012 Status: Endangered. Atlantic sturgeon live in rivers and coastal waters from Canada to Florida. Hatched in the freshwater of rivers, Atlantic sturgeon head out to sea as juveniles, and return to their birthplace to spawn, or lay eggs, when they reach adulthood. Atlantic sturgeon are slow-growing and late-maturing, and have been recorded to reach up to 16 feet in length and up to 60 years of age. Atlantic sturgeon were once found in great abundance, but their populations have declined greatly due to overfishing and habitat loss. Atlantic sturgeon were prized for their eggs, which were valued as high-quality caviar. During the late 1800s, people flocked to the Eastern United States in search of caviar riches from the sturgeon fishery, known as the “Black Gold Rush.” By the beginning of the 1900s, sturgeon populations had declined drastically. Close to 7 million pounds of sturgeon were reportedly caught in 1887, but by 1905 the catch declined to only 20,000 pounds, and by 1989 only 400 pounds of sturgeon were recorded. The most significant threats to Atlantic sturgeon are unintended catch in some commercial fisheries, dams that block access to spawning areas, poor water quality (which harms development of sturgeon offspring), dredging of spawning areas, water withdrawals from rivers, and vessel strikes. Atlantic sturgeon habitat can be disrupted or lost because of various human activities, such as dredging, dams, water withdrawals, saltwater intrusion (often caused by groundwater pumping from freshwater wells or drought), chemical contamination of sediments in rearing areas, and other development. Sturgeon need hard bottom substrates in freshwater reaches for spawning, so any activity that destroys those locations directly (e.g., dredging) or indirectly (e.g., sedimentation or saltwater intrusion) would affect Atlantic sturgeon habitat. To support all life stages, Atlantic sturgeon also require sufficient water quantities and water qualities sufficient to support all life stages, which are often impacted by the activities above.

General distribution:Source: Atlantic Sturgeon GARFO Master ESA Species Table dated 6/7/2018, found at https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/maps/garfo_master_esa_species_table_-_atlantic_sturgeon_06072018.pdf. Accessed on 10/10/2018)Atlantic Ocean waters and associated bays, estuaries, and coastal river systems from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida; only subadult and adult lifestages occur in marine waters, where they are typically found in waters 5-50 meters in depth (Stein et al. 2004; ASMFC TC 2007); subadults and adults may travel long distances in marine waters, aggregate in both ocean and estuarine areas at certain times of the year, and exhibit seasonal coastal movements in the spring and fall; distribution in rivers and inshore bays typically occurs from the estuary or river mouth generally up to the first impassible barrier (e.g., a dam or falls); Atlantic sturgeon generally use the deepest habitats available to them in rivers, but they have also been collected over shallow (2.5 meters), tidally influenced flats and substrates ranging from mud to sand and mixed rubble and cobble (Savoy and Pacileo 2003)

Estimated Range of Atlantic Sturgeon Distinct Population Segments (DPSs)



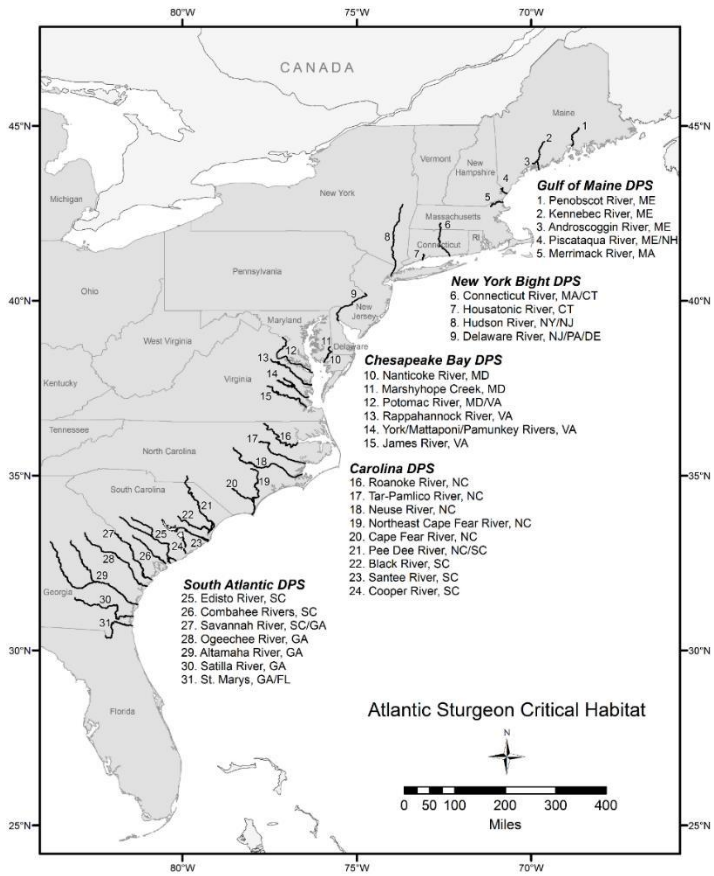
Waterbodies within the Action Areas: NMFS expect adult and sub-adult Atlantic sturgeon to use all the waters of the action area in VA for migration, foraging, and rest. The best available information indicates that spawning is limited to the James and York River systems, and as such spawning adults, ELS, and juvenile presence are limited to those water bodies.

Body of Water (State)	Distribution/Range in Watershed	Life Stages Present	Use of the Watershed	References
Chesapeake Bay (MD/VA)	Throughout the bay typically in spring through fall	juveniles, subadults, and adults	**Migration** - April-November for adults [5] and subadults [1]; year round for juveniles [2] 3]; these lifestages wander among coastal and estuarine habitats [5] **Foraging** - typically in areas where suitable forage and appropriate habitat conditions are present; typically tidally influenced flats and mud, sand and mixed cobble substrates [4]	1] Dovel and Berggren 1983; [2] Secor et al. 2000; [3] Welsh [4] Stein et al. 2004 [5] Horne and Stence 2016
Potomac River (MD/VA)	Up to Little Falls Dam (RKM 189)	juveniles, subadults, and adults potentially	**Spawning** - potentially occurs as three small juveniles [3] and a large mature female [2] have been captured and due to the presence of features necessary to support reproduction and recruitment	[1] Niklitschek and Secor 2005; [2] ASSRT 2007; [3] Kynard etal. 2007

		eggs, larvae, and YOY)	[1][2] **Rearing** - three juveniles have been captured [3] **Foraging** - where suitable forage and appropriate habitat conditions are present [2]	
Rappahannock River (VA)	Range not confirmed, but they have been documented in this river (likely throughout the entire river)	subadults and adults (potentially eggs, larvae, YOY, and juveniles)	**Spawning** - potentially occurs due to the capture of a male sturgeon in spawning condition in September 2015 and the presence of features necessary to support reproduction and recruitment [1][3] **Rearing** - may be used as a nursery for juveniles [2] **Foraging** - where suitable forage and appropriate habitat conditions are present [2]	[1] Bushnoe et al. 2005; [2] ASSRT 2007; [3] NMFS 2016
York River, including Mattaponi and Pamunkey River tributaries (VA)	York River - up to confluence with the Mattaponi and Pamunkey Rivers (RKM 55); Pamunkey River – up to RKM 150; Mattaponi River - up to RKM 120	eggs, larvae, YOY, juveniles, subadults, and adults	**Spawning** - potential for fall spawning due to the presence of features necessary to support reproduction in its tributaries (Mattaponi and Pamunkey Rivers) and recruitment in both the York River and its tributaries [1]; documented in the Pamunkey River through the capture of an adult female sturgeon in post-spawning condition in the fall and the presence of features necessary to support reproduction and recruitment [3]; may occur in the Pamunkey River as far al. 2014; [4] Kahn et al. 2014 Mattaponi River - up to RKM 120 upstream as RKM 150[4] **Rearing** - in freshwater reaches downstream of spawning sites; four age-0 Atlantic sturgeon were captured in the York River [2]; Juveniles likely present throughout the river year-round **Foraging** - where suitable forage and appropriate habitat conditions are present [1]	[1] Bushnoe et al. 2005; [2] Balazik et al. 2012; [3] Hager et al. 2014; [4] Kahn et al. 2014
James River (VA)	Up to Boshers Dam (RKM 182.3)	eggs, larvae, YOY, juveniles, subadults, and adults	**Staging -** likely done by fall spawners, during summer and fall in brackish water before and after the fall spawn (RKM 22- 107) [4] Spawning - both a spring (likely at RKM 90-95) [4] and fall spawning event (likely between RKM 105 and the fall line near Richmond, VA at RKM 155) [3] Rearing - freshwater reaches downstream of spawning locations[1][2]; Juveniles likely present throughout the river year-round **Foraging -** where suitable forage and appropriate habitat conditions are present [2]	[1] Florida Museum of Natural History 2004; [2] ASSRT 2007; [3] Balazik et al. 2012; [4] Balazik and Musick 2015
Appomattox River (VA), tributary of the James River	subadults and adults	Range not confirmed, but they have been documented in this river (likely up to Battersea Dam, RKM 21)	Foraging - where suitable forage and appropriate habitat conditions are present [1]	[1] The Hopewell News 2013

Critical Habitat of the Atlantic Sturgeon

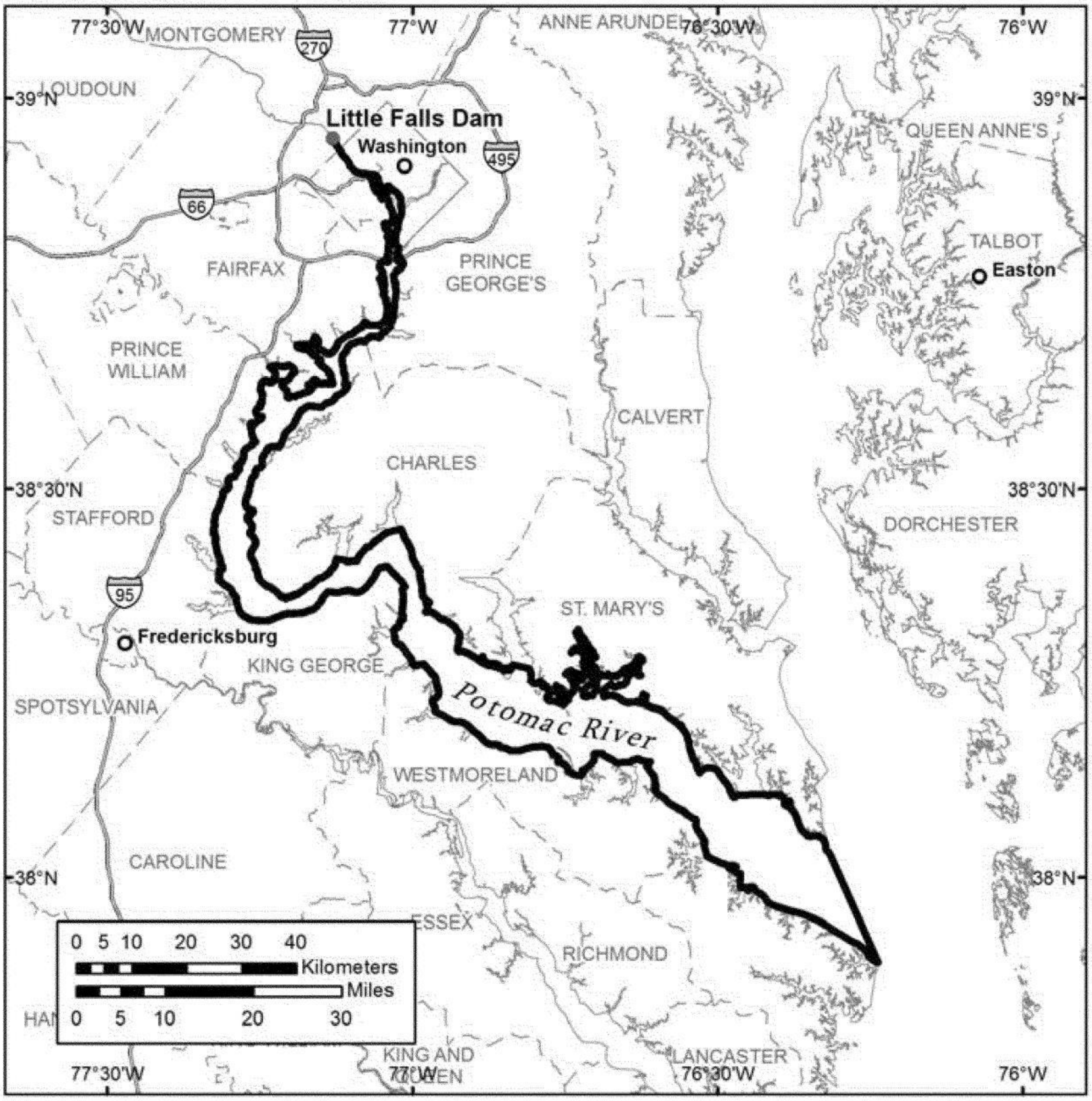
On August 17, 2017 NMFS issued a [final rule] to designate critical habitat for the threatened for several distinct population segment (DPS) of Atlantic sturgeon, including, the endangered Chesapeake Bay DPS of Atlantic sturgeon. The ESA authorizes USFWS and NMFS to designate critical habitat for federally-listed species, which is defined as habitat that is essential for the species' recovery.

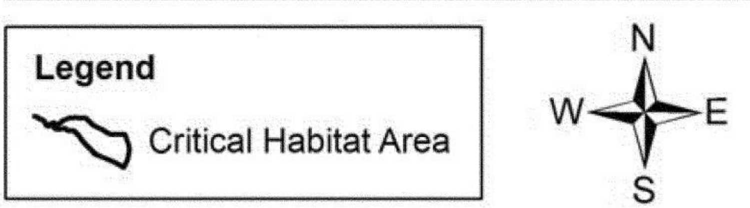


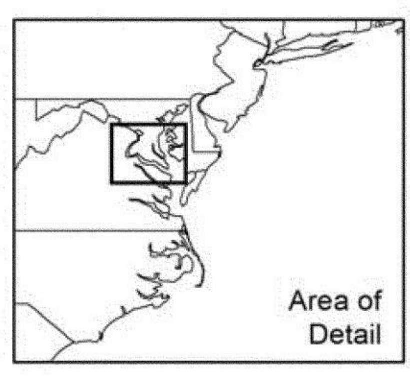
Atlantic sturgeon critical habitat is included in the *Critical habitat boundaries of the Chesapeake Bay* distinct population segment DPS. Critical habitat for the Chesapeake Bay DPS of Atlantic sturgeon is Rappahannock River from the U.S. Highway 1 Bridge, downstream to where the river discharges at its mouth into the Chesapeake Bay; York River from its confluence with the Mattaponi and Pamunkey rivers downstream to where the main stem river discharges at its mouth into the Chesapeake Bay as well as the waters of the Mattaponi River from its confluence with the York River and upstream to the Virginia State Route 360 Bridge of the Mattaponi River, and waters of the Pamunkey River from its confluence with the York River and upstream to the Nelson's Bridge Road Route 615 crossing of the Pamunkey River; James River from Boshers Dam downstream to where the main stem river discharges at its mouth into the Chesapeake Bay at Hampton Roads; Potomac River from the Little Falls Dam downstream to where the main stem river discharges at its mouth into the Chesapeake Bay. **See Federal Register** / Vol. 82, No. 158 / Thursday, August 17, 2017 / Rules and Regulations pages **39250 - 39253**

Chesapeake Bay Unit 2
Potomac River

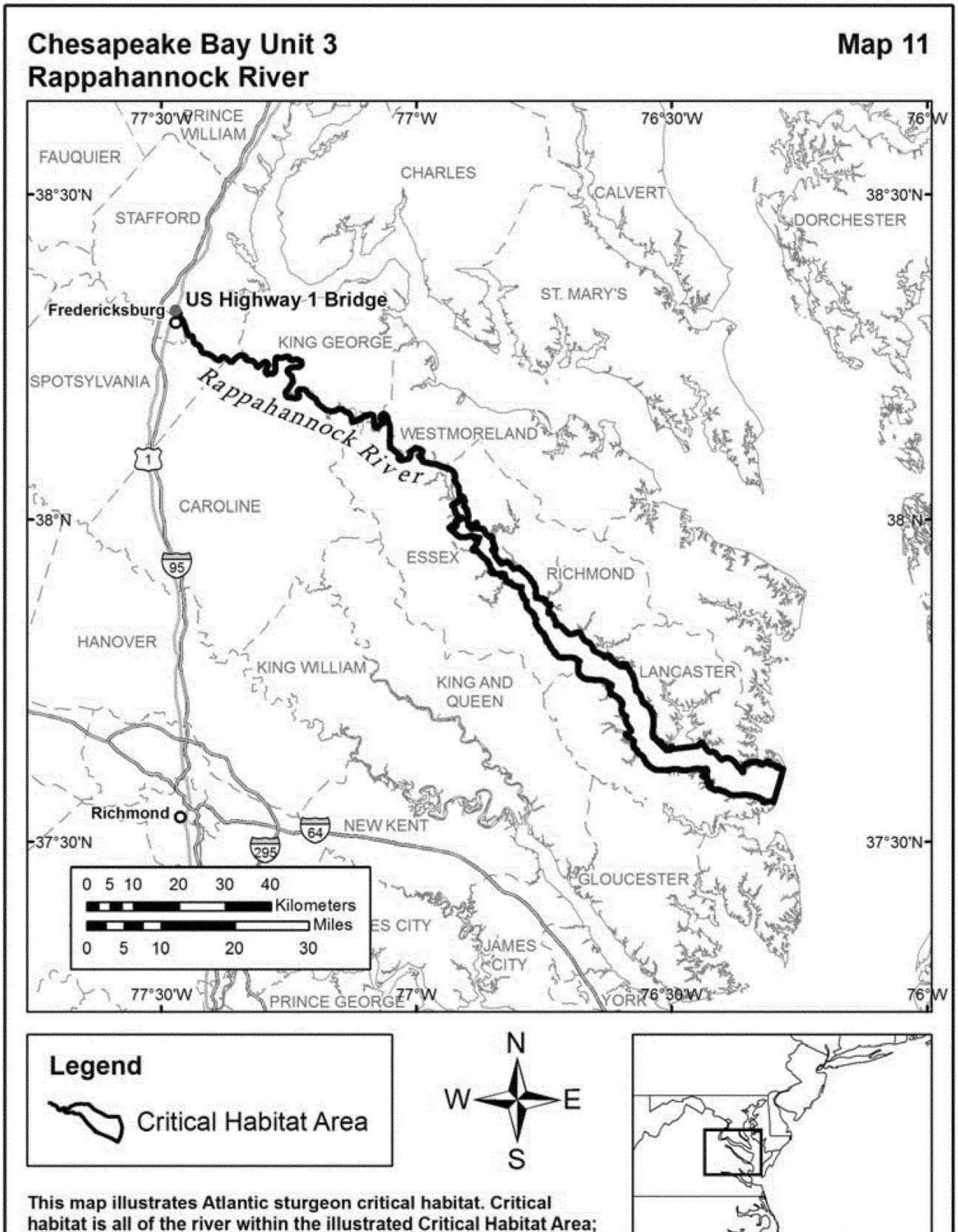
Map 10





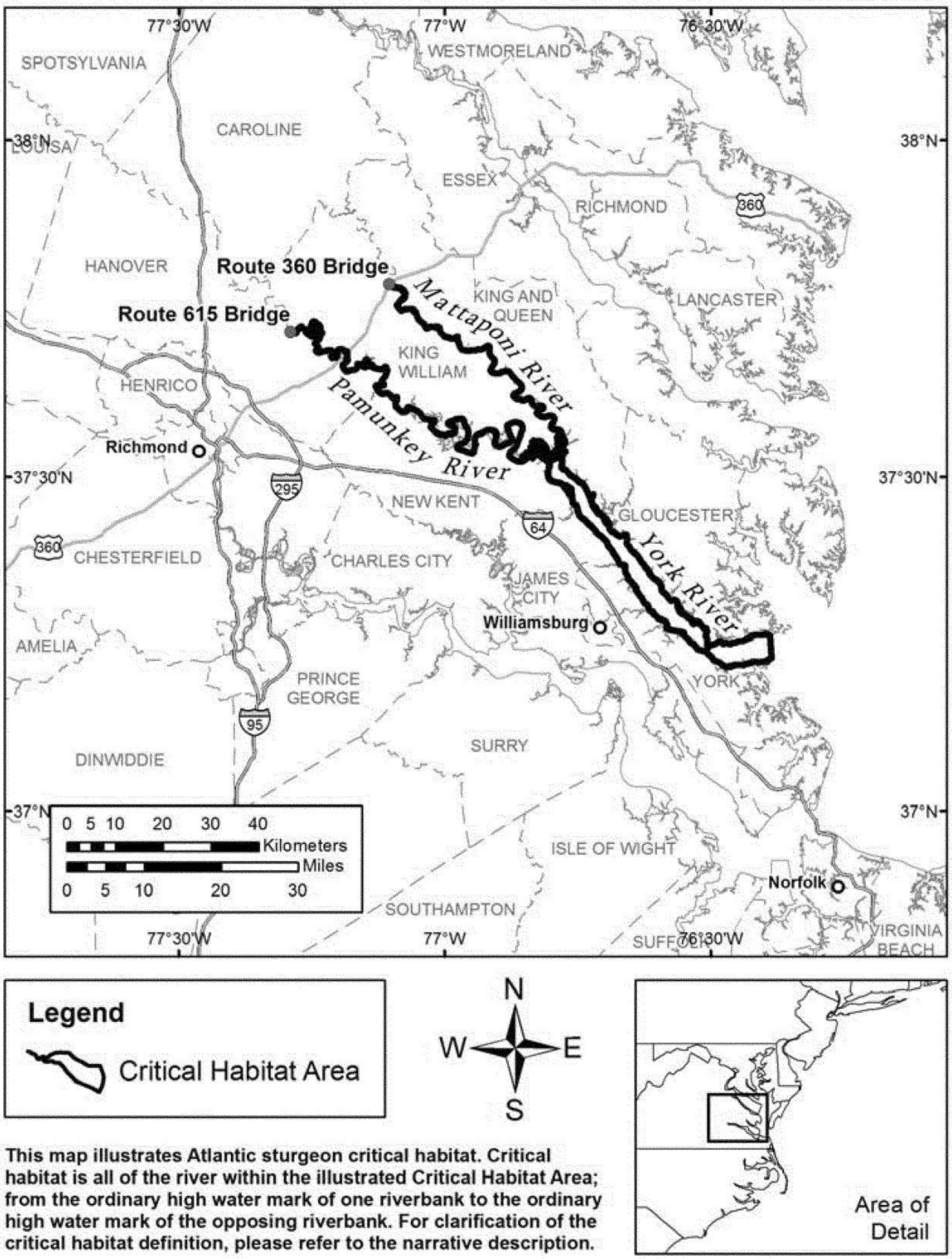


This map illustrates Atlantic sturgeon critical habitat. Critical habitat is all of the river within the illustrated Critical Habitat Area; from the ordinary high water mark of one riverbank to the ordinary high water mark of the opposing riverbank. For clarification of the critical habitat definition, please refer to the narrative description.



This map illustrates Atlantic sturgeon critical habitat. Critical habitat is all of the river within the illustrated Critical Habitat Area; from the ordinary high water mark of one riverbank to the ordinary high water mark of the opposing riverbank. For clarification of the critical habitat definition, please refer to the narrative description.

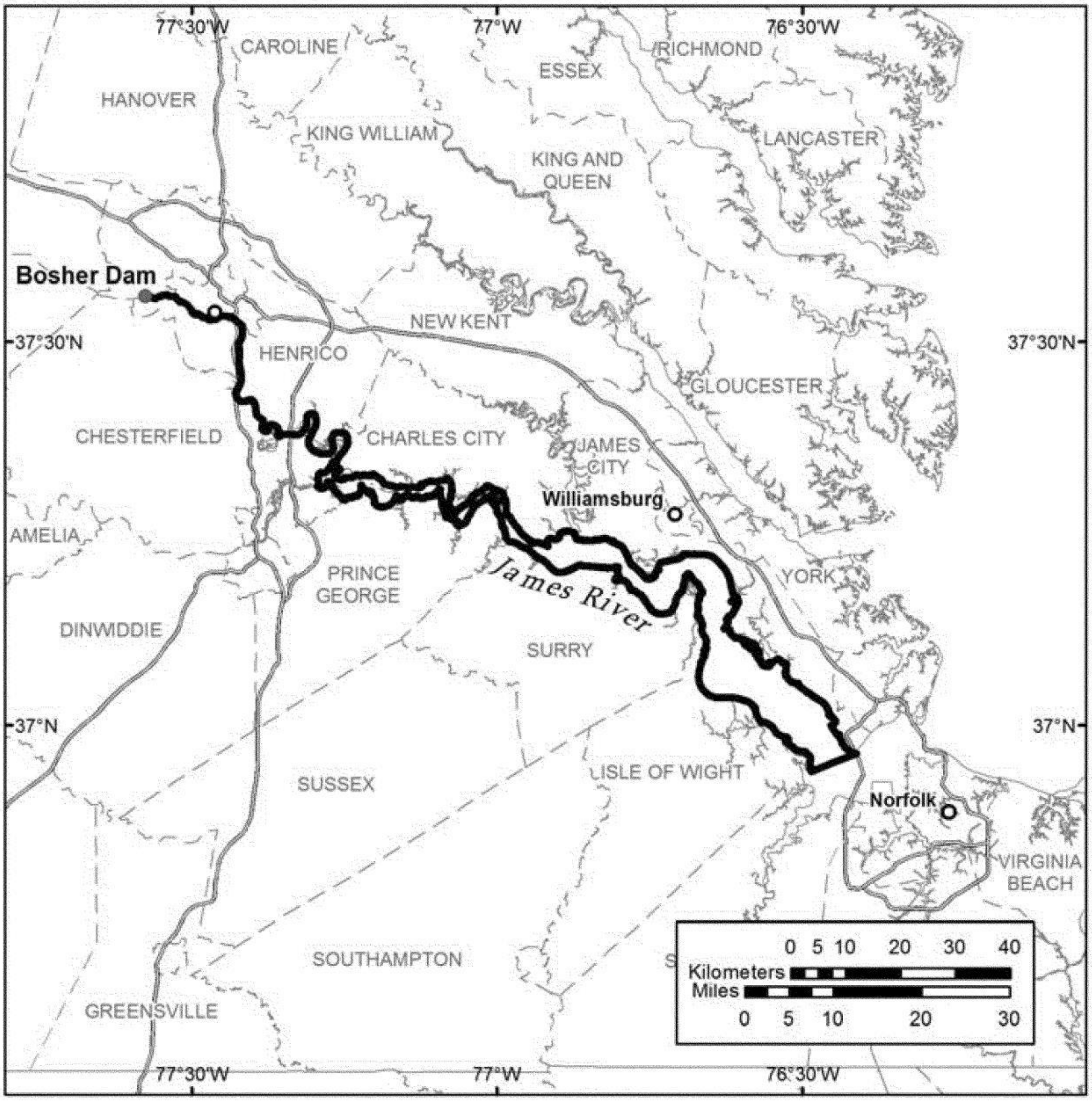
Chesapeake Bay Unit 4 — Map 12
York River, Mattaponi River, and Pamunkey River



This map illustrates Atlantic sturgeon critical habitat. Critical habitat is all of the river within the illustrated Critical Habitat Area; from the ordinary high water mark of one riverbank to the ordinary high water mark of the opposing riverbank. For clarification of the critical habitat definition, please refer to the narrative description.

Chesapeake Bay Unit 5 James River

Map 13

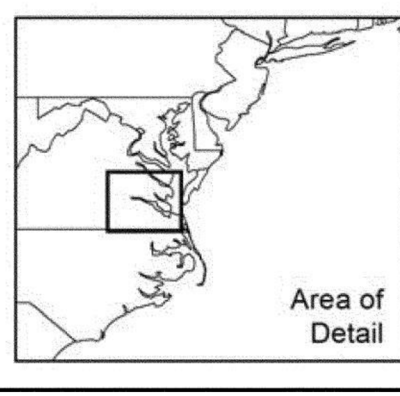


Legend

Critical Habitat Area

N W E S

This map illustrates Atlantic sturgeon critical habitat. Critical habitat is all of the river within the illustrated Critical Habitat Area; from the ordinary high water mark of one riverbank to the ordinary high water mark of the opposing riverbank. For clarification of the critical habitat definition, please refer to the narrative description.



NMFS has designated the Chesapeake Bay distinct population as endangered due to protracted population decline, limited spawning and continued impacts and threats. These threats include dredging, water quality degradation (e.g., runoff from agriculture, industrialization and dams), vessel strikes and catching by fisheries.

The final rule designates the critical habitat and defines and describes the habitat and its essential features (Physical and Biological Features (PBFs)) for Atlantic Sturgeon as follows:

- PBF 1: Hard bottom substrate for settlement of fertilized eggs, refuge, growth, and development of early life stages.

- PBF 2: Aquatic habitat with a gradual downstream salinity gradient of 0.5 to 30 parts per thousand and soft substrate downstream of spawning sites for juvenile foraging and physiological development.

- PBF 3: Water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support (l) unimpeded movement of adults to and from spawning sites, (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and (3) staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.

- PBF 4: Water, especially in the bottom meter of the water column, with temperature, salinity, and oxygen values that, combined, support (1) spawning, (2) annual and interannual adult, subadult, larval, and juvenile survival, and (3) larval, juvenile, and subadult growth, development, and recruitment.

The Nature Conservancy conducted a project that synthesized available literature, data and models describing distribution and habitat suitability for Atlantic sturgeon in the Delaware River and used that information as a basis for recommended habitat conditions (Moberg and DeLucia 2016). They recommend the following water. quality characteristics in order to support successful Atlantic sturgeon recruitment:

- Instantaneous Dissolved Oxygen 5.0 mg/L
- Temperature < 28^0 Celsius
- Salinity < 0.5 ppt and
- Discharge > July Q85 (4,000 cfs @ Ben Franklin), when average daily Dissolved Oxygen < 5.5 mg/L

Even though the project specifies the Delaware River, it can be assumed that these characteristics for species survival would also be applicable in the Virginia rivers.

Because the action area includes all major tributaries and coastal waters of VA, we have determined that all four PBFs are located within the overall action area.

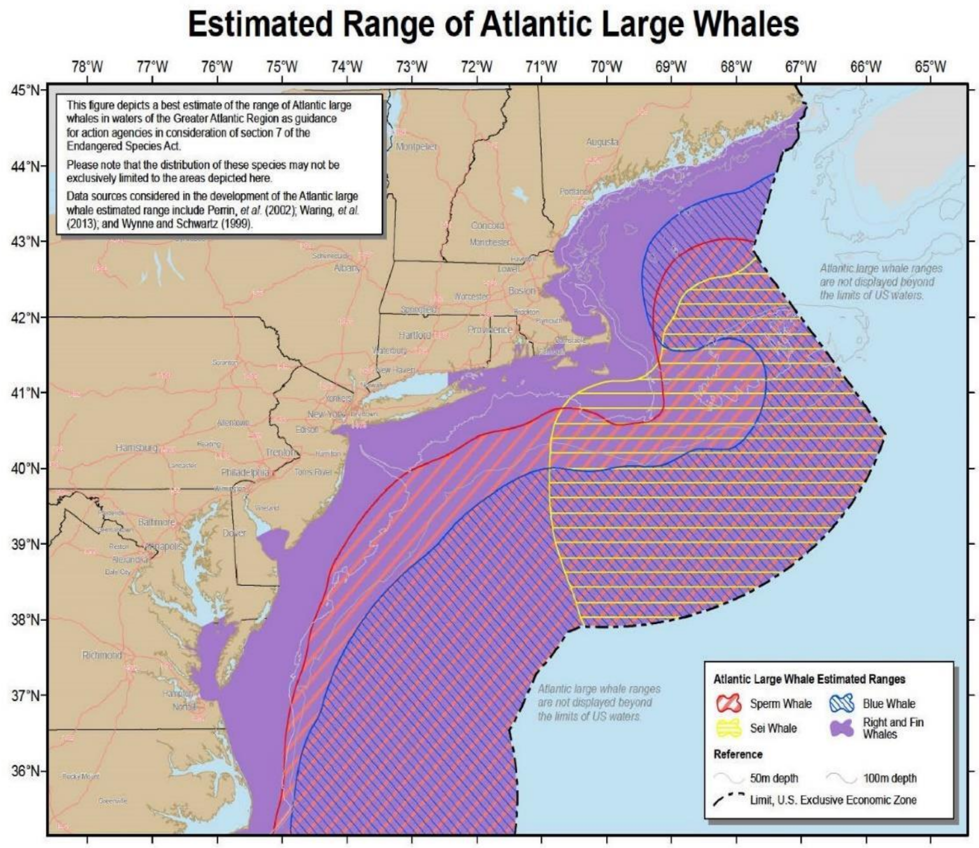
Whales

The Sei, Blue and Sperm whale are Species listed under the Endangered Species Act under the Jurisdiction of NMFS's Greater Atlantic Region (Main – Virginia) but are outside this Action Area. The Finback and North Atlantic are described below:

Finback Whale

Balaenoptera physalus

Year listed: 1970 **Status:** Endangered **General distribution:** Fin whales are common in waters of the U. S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward. Fin whales are migratory, moving seasonally into and out of high-latitude feeding areas, but the overall migration pattern is complex, and specific routes have not been documented. However, acoustic recordings from passive-listening hydrophone arrays indicate that a southward "flow pattern" occurs in the fall from the Labrador-Newfoundland region, past Bermuda, and into the West Indies (Clark 1995). Critical habitat in GAR: None



source: https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/maps/atlanticlargewhales2016.pdf.pdf Date acessed 2/28/2018

The Finback whale has a sleek streamlined body. And a distinctive coloration pattern: the back and sides of the body are black or dark brownish-gray, and the ventral surface is white. They are the second-largest species of whale, with a maximum length of about 75 feet in the Northern Hemisphere, and 85 feet in the Southern Hemisphere. Adults can weigh between 80,000-160,000 pounds (40-80 tons).

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics. Fin whales can be found in social groups of 2-7 whales and in the North Atlantic are often seen feeding in large groups that include humpback whales, minke whales, and Atlantic white-sided dolphins. Fin whales are large, fast swimmers and the killer whale (Orcinus orca) is their only non-human predator. During the summer, fin whales feed on krill, small schooling fish (e.g., herring, capelin, and sand lance), and squid by lunging into schools of prey with their mouth open, using their 50-100 accordion-like throat pleats to gulp large amounts of food and water. They then filter the food particles from the water using the 260-480 "baleen" plates on each side of the mouth. Fin whales fast in the winter while they migrate to warmer waters. Fin whales can live 80-90 years.

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics. They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally. No critical habitat rules have been published for the Finback whale.

Historically Major Threats include commercial whaling collisions with vessels, entanglement in fishing gear, reduced prey abundance due to overfishing, habitat degradation disturbance from low-frequency noise.

We expect that fin whales will be limited to coastal VA waters along the Atlantic seaboard with occasional transit near the mouth of the Chesapeake Bay.

North Atlantic Right Whale Eubalaena *glacialis*

Year listed: 1970; Listed as two separate, endangered species in 2008 - the North Pacific right whale (Eubalaena japonica) and North Atlantic right whale (Eubalaena glacialis)
Status: Endangered **General distribution:** Population ranges primarily from calving grounds in coastal waters of the southeastern United States to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence. Critical habitat in GAR: Expanded to include the Gulf of Maine and Georges Bank. Non- in Virginia.

North Atlantic right Whale are large baleen whales. Distinguishing features include a stocky body, black coloration (although some have white patches on their bellies), no dorsal fin, a large head (about 1/4 of the body length), strongly bowed lower lip, and callosities (raised patches of roughened skin) on their head. Two rows of long--up to 8 feet (2.4 m) --dark baleen plates hang from their upper jaw, with about 225 plates on each side. Their tail is broad, deeply notched, and all black with a smooth trailing edge. The can weigh up to 79 tons (158,000 lbs.; 71,700 kg) and are about 50 feet (15 m) in Length. Calves are about 14 feet (4.2 m) at birth.

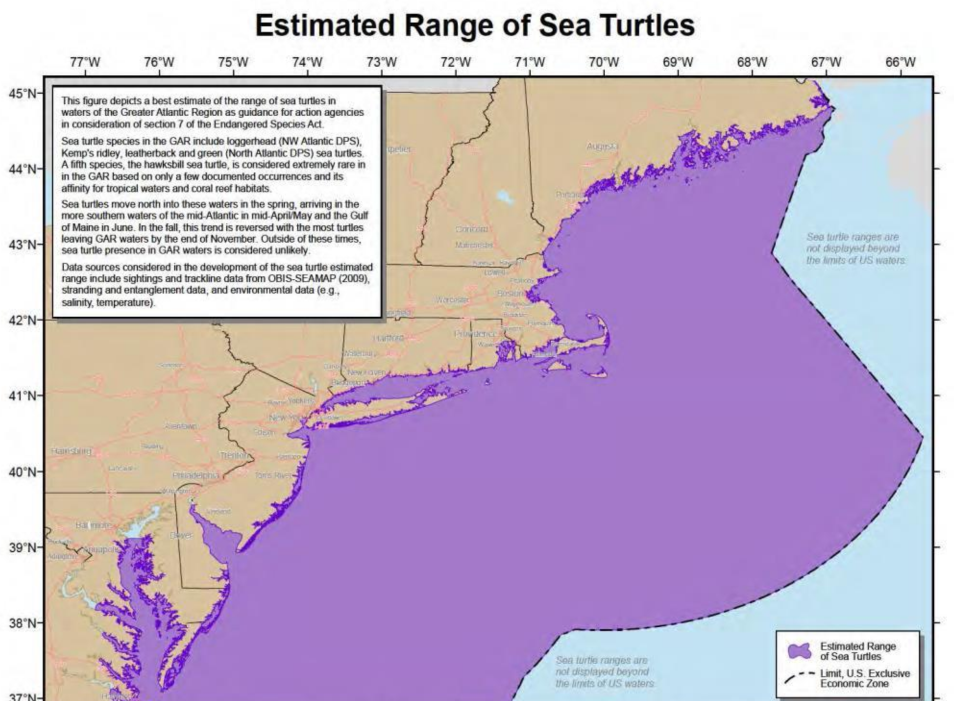
Right whales have occurred historically in all the world's oceans from temperate to subpolar latitudes. They primarily occur in coastal or shelf waters, although movements over deep waters are known. Right whales migrate to higher latitudes during spring and summer.

This long-lived, slowly reproducing whale species. Right whales generally feed from spring to fall, though, in certain areas, they may also feed in winter. Their primary food sources are zooplankton, including copepods, euphausiids, and cyprids. Unlike other baleen whales, right whales are skimmers; they feed by removing prey from the water using baleen while moving with their mouth open through a patch of zooplankton. Most known right whale nursery areas are in shallow, coastal waters. They Inhabit nearshore and offshore waters. Mainly coastal in the North Atlantic, occurs over the continental shelf in the North Pacific.   A few of the remaining North Pacific animals concentrated in relatively warm, shallow (50 to 80 m deep), well-stratified water in an extensive coccolithophore bloom of Emiliania huxleyi. Mother-calf pairs generally concentrate their summer feeding activities in relatively secluded areas away from sites frequented by other whales. Right whales generally feed from spring to fall, though, in certain areas, they may also feed in winter. Critical habitat in GAR: Great South Channel, east of Cape Cod and Cape Cod and Massachusetts Bays. None in Virginia.

Major Threats include: ship collisions, entanglement in fishing gear, habitat degradation, contaminants, climate and ecosystem change, disturbance from whale-watching activities, noise from industrial activities They also face natural threats from predators, such as large sharks and killer whales, which may affect the population.

NMFS expects that right whales will be limited to coastal VA waters along the Atlantic seaboard with occasional transit near the mouth of the Chesapeake Bay.

Sea Turtles



Source: GARFO Master ESA Species Table - Sea Turtles, found at https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/maps/garfo master esa species table - sea turtles 111516.pdf. Accessed on 10/15/2018)

While sea turtles occur year-round off the southeastern United States, they are generally present in marine and estuarine waters of the GAR from April through November. As water temperatures warm in the spring, sea turtles begin to migrate to nearshore waters and up the U.S. Atlantic coast, occurring in Virginia as early as April/May and in the Gulf of Maine in June. The trend is reversed in the fall with some animals remaining in the GAR until late fall. Outside of these times, sea turtle presence in GAR waters is considered unlikely, although juvenile sea turtles routinely strand on GAR beaches during colder months (i.e., from October to January) as a result of cold-stunning. Nesting is extremely limited in the GAR. Typically, juveniles and, to a lesser extent, adults are present in the GAR. Source https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/maps/seaturtles2016.pdf.pdf. Accessed on 10/15/2018.

Four species (loggerhead, green, Kemp's ridley, and leatherback) found throughout continental shelf and slope waters of the Northwest Atlantic Ocean; tropical to boreal waters, preferred temperatures greater than 10°C; northward and inshore movement into waters of the Greater Atlantic Region begins in the spring, with turtles arriving into Mid-Atlantic waters in mid-

April/May and into Gulf of Maine waters in June; in the fall, this trend is reversed with most turtles leaving the region's waters by the end of November; outside of these times, sea turtle presence in the region's waters is considered unlikely aside from cold-stunned individuals that fail to migrate south (see below); a fifth species (hawksbill) is considered extremely rare in the region based on only a few documented occurrences and its affinity for tropical waters and coral reef type habitats. Below is information on the presence of sea turtles in the action area.

State	**Coastal / Inshore Areas of Regular Occurrence**	**Likely Presence**	**Life Stages Present**	**Behaviors Anticipated to Occur**
DE /MD /VA	Coastal waters off Virginia Beach, coastal waters and back bays of the DelMarVa Peninsula, Chesapeake Bay, Tangier Sound, and lower portions of southern Chesapeake Bay tributaries (e.g., James, York, Rappahannock, and Potomac Rivers)	May to November (note: cold stunning of hard-shelled sea turtles occurs annually from October to January)	Loggerhead (Northwest Atlantic DPS) -Pelagic and benthic adults, and juveniles, adults Green (North Atlantic DPS) -Juveniles and adults Kemp's ridley -Juveniles only Leatherback - Juveniles and adults	**Foraging** Loggerhead (Northwest Atlantic DPS) - Pelagic and benthic juveniles - omnivorous on bottom and surface - Sub-adults and adults - benthic invertebrates along the coast Green (North Atlantic DPS) - Juveniles - Omnivorous along coasts and in protected bays and lagoons -Adults -Herbivorous in nearshore areas Kemp's ridley - Juveniles - Benthic invertebrates in protected coastal areas Leatherback - Juveniles and adults - Primarily prey on jellyfish in offshore oceanic or coastal neritic areas **Nesting** North of North Carolina, sea turtle nesting is rare (there is occasional loggerhead nesting in Virginia, but no established nesting beaches further north)

1 Effects Assessment Methodologies

1.1 Acute Effect Assessment Methodology: Direct Effects to Freshwater Life Stages of Anadromous Species

The protectiveness of the freshwater acute ammonia and freshwater acute cadmium criteria magnitudes was assessed by identifying or estimating acute toxicity values (i.e., LC_{50}) for Virginia aquatic listed species that were then adjusted to represent protective low effect threshold concentrations as described below. Acute toxicity values used to develop the acute effects assessments were obtained from Appendix A of their respective 304(a) aquatic life criteria documents (Ammonia, USEPA 2013; Cadmium, USEPA 2016) and were specifically used to derive the acute criterion (i.e., bold values in Appendix A of USEPA 2013 and underlined values in USEPA 2016). These data were identified from EPA's ECOTOX database, the open and grey literature, and have been subjected to extensive data quality review (see Stephan et al. 1985 for data quality objectives). Acute ammonia values have been normalized to a pH of 7 (all freshwater animals), consistent with criteria derivation (USEPA 2013). Acute cadmium toxicity data have been normalized to a total hardness of 100 mg/L as $CaCO_3$ consistent with criteria derivation (USEPA 2016). Ideally, species-specific toxicity data would be available for listed species of concern to support an acute effects assessment; however, data limitations often required use of surrogate toxicity data.

EPA considered acute toxicity data at the closest taxonomic level possible to calculate geometric mean acute toxicity values for each species assessed (i.e., LC_{50}). Considering surrogate toxicity data at the most phylogenetically-related taxonomic level possible accounts for genetically-derived traits conserved across taxa that may directly influence sensitivity to a pollutant. Geometric mean acute toxicity values at the genus were calculated as the geometric mean of species-level geometric mean values, since these mean values are meant to represent the sensitivity for a particular taxon. Species-specific and surrogate acute toxicity data obtained from Appendix A of USEPA (2013) and USEPA (2016) represent sensitivity expressed as a concentration that will acutely affect half of the species population. Acute toxicity data (expressed as LC_{50}) were transformed to an acute minimum effect threshold concentration (i.e., LC_5) which represents a concentration that is expected to affect 5% of the test population of a listed species under continuous exposure conditions, typically 48 to 96 hours depending on the species tested. Representing acute minimum effect thresholds as an LC_5 value is conservative because high-quality toxicity tests are considered acceptable even when up to 10% mortality is observed in the control treatment (organisms not exposed to the pollutant). Moreover, the use of a five percent toxicity value to represent an acute minimum effect threshold to an individual is consistent with reasonable and prudent measures (RPMs) outlined in a recent biological opinion (NOAA 2012).

Raw empirical acute toxicity data may be used to calculate LC_5 values directly from the concentration-response (C-R) curves of the listed species-specific toxicity tests, when available. However, not all acute tests provide concentration-response data. Therefore, species-specific, or surrogate LC_{50} values (which represent listed species 50% effect level), were transformed to an acute minimum effect threshold concentration through an acute taxonomic adjustment factor

(TAF) or an acute mean adjustment factor (MAF). An acute TAF was calculated by averaging (geometric mean) the ratios of LC_{50}:LC_5 from chemical-specific acute toxicity tests conducted using species in the closest possible phylogenetic proximity (same species, genus, family, or order) as the listed species that is being assessed (genus-, family-, and order-level acute TAFs were calculated as the geometric mean of lower taxonomic-level geometric mean acute TAFs to ensure adequate representation of all lower-level taxa for a particular taxon). When data availability did not allow for the development of an acute TAF within the same order as the species being assessed, EPA considered applying an acute invertebrate or vertebrate TAF (depending on whether the listed species assessed was an invertebrate or vertebrate). The acute invertebrate TAF and the acute vertebrate TAF were calculated as the geometric mean of genus-level LC_{50}:LC_5 ratios of invertebrates and vertebrates, respectively. An acute MAF was used to adjust species effect concentrations (i.e., LC_{50}) to low effect threshold concentrations (i.e., LC_5) when; 1) an acute TAF was not available within the same order as the listed species being assessed and 2) when the acute invertebrate TAF and the acute vertebrate TAF were not significantly different via a two-sample t-test assuming unequal variances ($\alpha = 0.05$). The acute MAF was calculated as the geometric mean of all genus-level LC_{50}:LC_5 ratios available. Acute invertebrate and vertebrate TAFs and the acute MAF were calculated as the geometric mean of their respective genus-level LC_{50}:LC_5 ratios to limit the influence of LC_{50}:LC_5 ratios from species that are overly represented in a dataset, similar to criteria derivation (Stephan et al. 1985).

Listed species-specific or surrogate LC_{50} values were then divided by an appropriate adjustment factor (i.e., acute TAF or acute MAF depending on data availability) to derive an acute minimum effect threshold concentration. Dividing LC_{50} values by an adjustment factor to identify a minimum-level effect concentration is an approach that is fundamentally similar to acute criteria derivation[1], but is more specific to the chemical and species assessed. Acute minimum effect threshold concentrations were then compared to corresponding criteria magnitudes (i.e., criterion maximum concentration [CMC]) to assess potential direct adverse effects of ammonia or cadmium exposures at the acute criterion concentration over conservative exposure durations.

The freshwater ammonia CMC is both pH- and temperature-dependent due to ammonia speciation differences. Vertebrate sensitivity to ammonia in freshwaters, however, is only dependent on pH, with tolerance decreasing as pH increases (see USEPA 2013). At any given temperature (e.g., 20°C), the freshwater ammonia CMC decreases with increasing pH. Figure 1-1

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[1]The Final Acute Value (FAV; fifth centile of genus mean acute values) is divided by 2.0 to derive the Criterion Maximum Concentration (CMC). The FAV was divided by 2.0 to ensure the CMC is representative of a concentration that will not severely adversely affect too many organisms. To support the development of the 1985 Guidelines, a Federal Register notice published in 1978 (Vol 43, pp. 21506-21518; USEPA 1978) outlined the derivation of a generic LC_{50} to LC_{low} (i.e., 0-10% effect) adjustment factor of 0.44 (or divide by 2.27). The adjustment factor of 2.27 was derived as the "*geometric mean of the quotients of the highest concentration that killed 0-10% of the organisms divided by the LC_{50} in 219 acute toxicity tests*." The geometric mean adjustment factor (2.27) outlined in the 1978 Federal Register notice was subsequently rounded to 2.0 in the 1985 Guidelines (Stephan et al. 1985).

depicts the change in acute criterion magnitude with pH at a temperature of 20°C, and how the acute minimum effect threshold for Atlantic sturgeon (see Section 2.1.1) changes with the criterion magnitude proportionally (factor difference of 6.557 at 20°C). The acute effects assessment was developed using toxicity data normalized to reference conditions (pH = 7, temperature = 20°C) and compared to the corresponding CMC in those same reference conditions. Because species sensitivity and the CMC both change similarly across water chemistries, conclusions based on reference conditions translate to other surface waters.

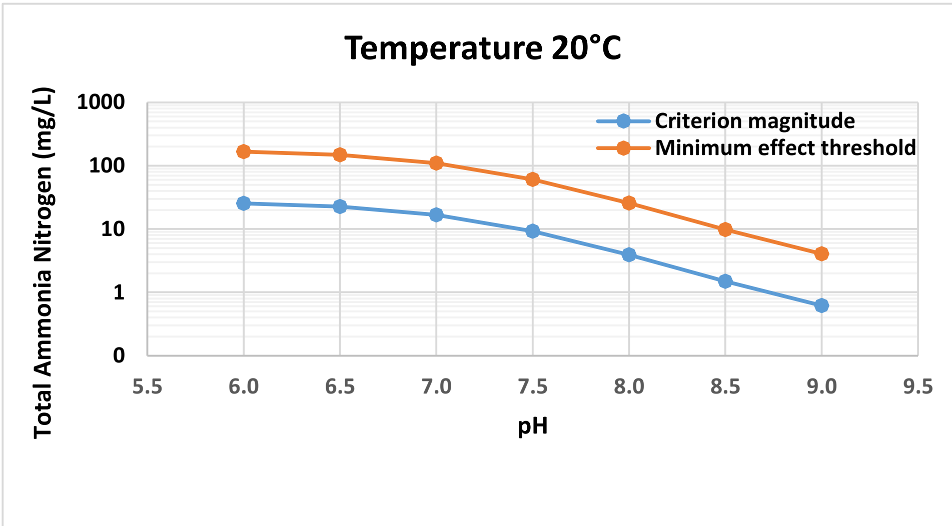

Figure 1-1. Acute ammonia criterion magnitudes extrapolated across a pH gradient at pH at a water temperature of 20°C. The acute minimum threshold concentration calculated for Atlantic sturgeon (see Section 2.1.1) is overlaid on the acute criterion magnitude. The freshwater acute ammonia criterion magnitude and the Atlantic sturgeon acute minimum effect threshold both decrease with increasing pH. The factor difference between the acute criterion magnitude and acute minimum effect threshold for Atlantic sturgeon is 6.557.

In contrast to ammonia, species sensitivity to cadmium in freshwaters is only dependent on water hardness, with tolerance increasing as hardness increases (see USEPA 2016). The freshwater cadmium CMC increases with increasing hardness across the range of hardness in typical ambient surface water (acute toxicity hardness slope 0.9789). Figure 1-2 depicts the change in the cadmium CMC across water hardness of 25 to 400 mg/L as $CaCO_3$, and how the acute minimum effect threshold for Atlantic sturgeon (from Section 3.1.1) changes with the criterion magnitude proportionally (factor difference of 7.694). The acute freshwater cadmium effects assessment was developed using toxicity data normalized to a reference condition (hardness = 100 mg/L) and compared to the corresponding CMC in those same reference conditions. Because species sensitivity to acute cadmium exposures in freshwater and the freshwater cadmium CMC both change similarly across water chemistries, conclusions based on reference conditions translate to other water chemistries.

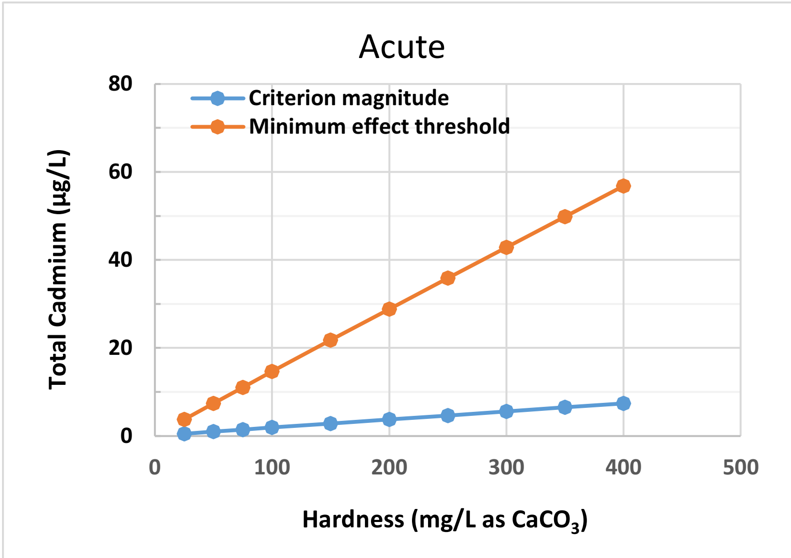

Figure 1-2. Acute cadmium criterion magnitudes extrapolated across a gradient of water hardness, overlaid with the Atlantic sturgeon acute minimum effect threshold concentration (see Section 3.1.1). The freshwater acute cadmium criterion magnitude and the Atlantic sturgeon acute minimum effect threshold both increase with increasing water hardness. The factor difference between the acute criterion magnitude and acute minimum effect threshold for Atlantic sturgeon is 7.694.

Assessing an acute criterion magnitude alone does not consider the duration and frequency components of the criterion and represents an overly conservative exposure scenario that assumes a pollutant concentration in all Virginia freshwaters will be at the acute criterion magnitude indefinitely. If a listed species acute minimum effect threshold concentration is greater than the corresponding acute criterion magnitude, then a refined assessment and consideration of the criterion duration and realistic exposure is not necessary, and approval of the acute criterion is Not Likely to Adversely Affect (NLAA) (i.e., effects are too small to be detected (insignificant) or extremely unlikely to occur (discountable)) that particular listed species through direct acute effects in freshwaters.

1.2 Chronic Effect Assessment Methodology: Direct Effects to Freshwater Life Stages of Anadromous Species

The protectiveness of the chronic freshwater ammonia and chronic freshwater cadmium criteria magnitudes was assessed by identifying or estimating chronic toxicity values (i.e., EC_{20}) for Virginia aquatic listed species that were then adjusted to represent protective low effect threshold concentrations as described below. Ammonia chronic toxicity values used to develop the chronic effects assessments were obtained from Appendix B of the ammonia 304(a) aquatic life criteria document (USEPA 2013) and cadmium chronic toxicity data were obtained from Appendix C of the cadmium criteria document (USEPA 2016). These data were specifically used to derive the ammonia and cadmium criteria (i.e., bold values in Appendix B or underlined values in Appendix C, respectively) and were identified from EPA's ECOTOX database, the open and grey literature, and have been subjected to extensive data quality review (see Stephan et al. 1985 for data quality objectives). Chronic ammonia toxicity data (i.e., EC_{20}) used to support the effects assessment have been normalized to a pH of 7 (all freshwater species) and 20°C (freshwater invertebrates only), consistent with criteria derivation (USEPA 2013) and chronic cadmium toxicity data have been normalized to a total hardness of 100 mg/L as $CaCO_3$, consistent with criteria derivation (USEPA 2016).

Ideally, species-specific toxicity data would be available to support a chronic effects assessment; however, data limitations often required use of surrogate toxicity data. EPA considered chronic toxicity data at the closest taxonomic level to calculate geometric mean chronic toxicity values for each species assessed (i.e., EC_{20}). Considering surrogate toxicity data at the most phylogenetically-related taxonomic level possible accounts for genetically-derived traits conserved across taxa that may directly influence sensitivity to a pollutant. Geometric mean chronic toxicity values at the genus-, family-, and order-level were calculated as the geometric mean of lower taxonomic-level geometric mean values, since these mean values are meant to represent the sensitivity for a particular taxon. In certain cases, empirical chronic toxicity data were not available for surrogate species occurring within the same order as the listed species assessed. In these cases, appropriate acute data were transformed by an acute to chronic ratio (ACR) to estimate a chronic toxicity value (i.e., EC_{20}).

Unlike acute criteria derivation, which typically uses a generic LC_{50} to LC_{low} adjustment factor (i.e., 2.0[1]; Stephan et al. 1985), chronic criteria are based directly on chronic effect concentrations (e.g., EC_{20}) and do not incorporate a generic EC_x to EC_{low} adjustment factor. However, a concentration that results in chronic effects to 20% of a listed species population may not be considered acceptable for listed species. Therefore, a similar convention used for the acute assessment methodology was applied to the chronic effects assessment methodology to determine a chronic minimum effect threshold concentration (i.e., EC_5) from chronic toxicity values.

Raw empirical chronic toxicity data may be used to calculate EC_5 values directly from the concentration-response (C-R) curves of the listed species-specific toxicity tests, when available. However, not all chronic tests provide concentration-response data. Therefore, species-specific, or surrogate EC_{20} values (which represent listed species 20% effect level), were transformed to a chronic minimum effect threshold concentration through the use of a chronic taxonomic adjustment factor (TAF) or a chronic mean adjustment factor (MAF), in the same manner as the acute adjustment factors described previously. Specifically, a chronic TAF was calculated by averaging (geometric mean) the ratios of EC_{20}:EC_5 from chemical specific chronic toxicity tests conducted using species in the closest possible phylogenetic proximity (same species, genus, family, or order) as the listed species that is being assessed (genus-, family-, and order-level chronic TAFs were calculated as the geometric mean of lower taxonomic-level geometric mean chronic TAFs to ensure adequate representation of all lower-level taxa for a particular taxon). When data availability did not allow for the development of a chronic TAF within the same order as the species being assessed, EPA considered applying a chronic invertebrate or vertebrate TAF (depending on whether the species assessed was an invertebrate or vertebrate). The chronic invertebrate TAF and the chronic vertebrate TAF were calculated as the geometric mean of genus-level EC_{20}:EC_5 ratios of invertebrates and vertebrates, respectively. A chronic MAF was used to adjust species effect concentrations (i.e., EC_{20}) to low effect threshold concentrations (i.e., EC_5) when; 1) a chronic TAF was not available within the same order as the listed species being assessed and 2) when the chronic invertebrate TAF and the chronic vertebrate TAF were not significantly different via a two-sample t-test assuming unequal variances ($\alpha = 0.05$). The chronic MAF was calculated as the geometric mean of all genus-level EC_{20}:EC_5 ratios available. Chronic invertebrate and vertebrate TAFs and the chronic MAF were calculated as the geometric mean of their respective genus-level EC_{20}:EC_5 ratios to limit the influence of EC_{20}:EC_5 ratios from species that are overly represented in a dataset, similar to criteria derivation (Stephan et al. 1985).

Listed species-specific or surrogate EC_{20} values were then divided by an appropriate adjustment factor (i.e., chronic TAF or chronic MAF depending on data availability) to derive a chronic minimum effect threshold concentration. Chronic minimum effect threshold concentrations were then compared to the corresponding criterion magnitude (i.e., criterion continuous concentration [CCC]) to assess potential adverse effects of ammonia or cadmium exposures at the chronic criterion concentration.

The freshwater ammonia CCC is pH- and temperature-dependent. Vertebrate sensitivity to ammonia in freshwaters, however, is only dependent on pH, with tolerance decreasing as pH increases (see USEPA 2013). At any given temperature (e.g., 20°C), the freshwater ammonia CCC decreases with increasing pH. Figure 1-3 depicts the change in the ammonia CCC across waters with different pH and how the chronic minimum effect threshold for Atlantic sturgeon (see Section 2.1.2) changes proportionally with the criterion magnitude (factor difference of 6.555). Because species sensitivity and the CCC both change similarly, conclusions based on reference conditions translate to other surface waters.

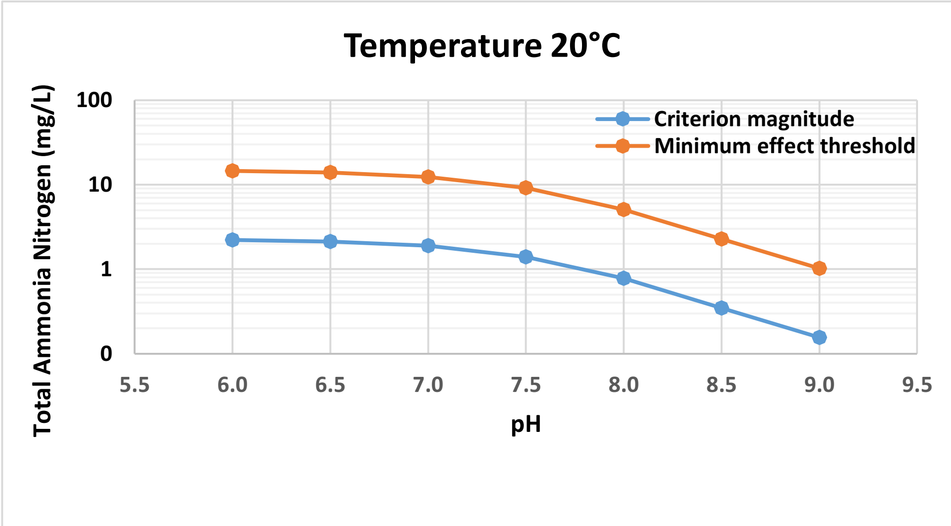

Figure 1-3. Chronic ammonia criterion magnitude extrapolated across a pH gradient (at a water temperature of 20°C) with the Atlantic sturgeon (see Section 2.1.2) chronic ammonia minimum effect threshold concentration overlaid. The factor difference between the chronic criterion magnitude and chronic minimum effect threshold for Atlantic sturgeon is 6.555.

In contrast to ammonia, species sensitivity to cadmium in freshwater is dependent on water hardness, with tolerance increasing as hardness increases (see USEPA 2016). The cadmium CCC increases with increasing hardness across the range of hardness typical of natural ambient surface water, but with a slightly shallower slope than for the CMC (chronic toxicity hardness slope 0.7977). Figure 1-4 depicts the change in the cadmium CCC across water hardness and how the Atlantic sturgeon chronic minimum effect threshold (see Section 3.1.2) changes with the chronic freshwater cadmium criterion magnitude proportionally (factor difference of 3.432). The chronic effects assessment was developed using toxicity data normalized to a reference condition (hardness = 100 mg/L) and compared to the corresponding CCC in those same reference conditions. Because species sensitivity and the CCC both change similarly across water chemistries, conclusions based on reference conditions translate to other water chemistries.

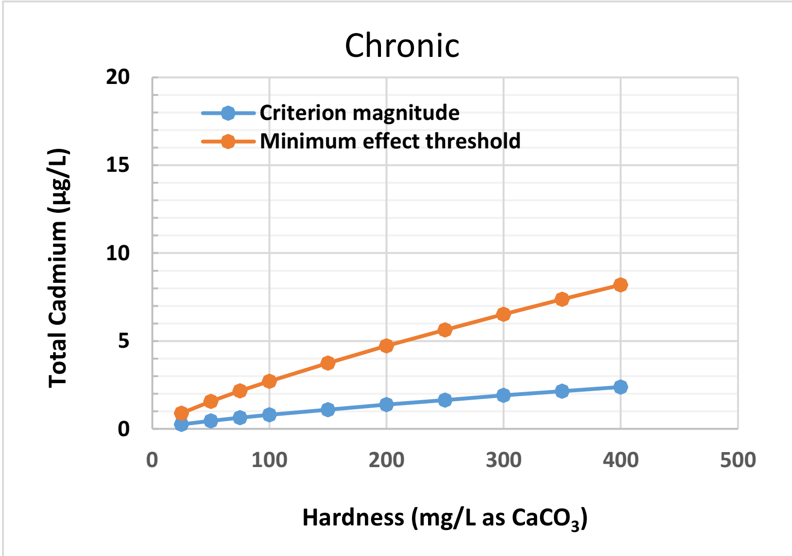

Figure 1-4. Chronic cadmium criterion magnitudes extrapolated across a gradient of water hardness overlaid with the Atlantic sturgeon chronic minimum effect threshold concentration (see Section 3.1.2). The criterion magnitude increases and the Atlantic sturgeon chronic minimum effect threshold both increase with increasing water hardness. The factor difference between the chronic criterion magnitude and chronic minimum effect threshold for Atlantic sturgeon is 3.432.

Assessing a chronic criterion magnitude alone does not consider the duration and frequency components of the criterion and represents an overly conservative exposure scenario that assumes a pollutant concentration in all Virginia freshwaters will be at the chronic criterion magnitude indefinitely. If a listed species chronic minimum effect threshold concentration is greater than the corresponding chronic criterion magnitude, then a refined assessment and consideration of the criterion duration and realistic exposure is not necessary, and approval of the chronic criterion is Not Likely to Adversely Affect (NLAA) (i.e., effects are too small to be detected (insignificant) or extremely unlikely to occur (discountable)) that particular listed species through direct chronic effects in freshwaters.

1.3 Acute and Chronic Effect Assessment Methodology: Direct Effects to Estuarine/Marine Species and Saltwater Life Stages of Anadromous Species

In additional to the freshwater cadmium criterion, Virginia has also proposed to adopt the acute and chronic cadmium criterion for estuarine/marine waters (USEPA 2016). Given relative data limitations associated with saltwater toxicity data, the acute and chronic estuarine/marine cadmium criteria were assessed together in a qualitative approach by considering limited exposure potential and previous biological opinions.

Virginia has not proposed to adopt or update estuarine/marine ammonia criteria. Freshwater and terrestrial species with range or critical habitat in Virginia waters are subject to consultation with U.S. Fish and Wildlife Service.

1.4 Indirect Effects: Assessment of Acute and Chronic Criteria

Following assessment of direct acute and chronic effects, EPA considered and assessed potential indirect effects of the water quality standard approval actions on anadromous and estuarine/marine species. To assess potential indirect effects, EPA considered conservatisms associated with criteria derivation and implementation as well as potential effects to listed animal prey items.

1.5 Listed Species: Final Effects Determinations

Final effect determinations were based on direct and/or indirect effects of EPA's approval of the acute and chronic ammonia (freshwater) and cadmium (freshwater and estuarine/marine) water quality standards in Virginia. EPA considered direct acute and chronic effects as well as indirect effects to make a final effects determination.

1.6 Critical Habitat: Effects Assessment and Final Critical Habitat Effects Determinations

Following listed species final effects determinations, EPA assessed designated critical habitats pertaining to anadromous and estuarine/marine species with critical habitats overlapping the action area. EPA considered Physical and Biological Features (PBFs, formally Primary Constituent Elements [PCEs]) essential to critical habitat and potential effects to listed species prey items (evaluated through the indirect effects assessment) to determine if the proposed action is *Likely to Adversely Modify* critical habitat or if the proposed action is *Not Likely to Adversely Modify* critical habitat.

2 Ammonia Effects Assessment

2.1 Sturgeon: Shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus oxyrinchus*)

2.1.1 Sturgeon Acute Ammonia Effects Assessment: Freshwater

2.1.1.1 Identifying Sturgeon Acute Ammonia Data

High-quality species-level acute data (i.e., bold values in Appendix A of the 2013 freshwater ammonia 304(a) aquatic life criteria document) were not available for the Atlantic sturgeon. Therefore, the species-level acute toxicity data for shortnose sturgeon were applied as a genus-level surrogate toxicity value for the Atlantic sturgeon. The shortnose sturgeon Species Mean Acute Value (SMAV) is composed of a single, definitive LC_{50} value (156.7 mg/L, normalized to pH 7) from a test with a sensitive life stage (Fontenot et al. 1998) and represents the *Acipenser* Genus Mean Acute Value (GMAV) applicable to the Atlantic sturgeon species (Table 2-1).

Table 2-1. Data used to calculate the SMAV and GMAV representative of shortnose and Atlantic sturgeon acute sensitivity to ammonia.

Order	Family	Species	SMAV (mg/L)[a]	GMAV (mg/L)[a]
Acipenseriformes	Acipenseridae	Shortnose sturgeon, *Acipenser brevirostrum*	156.7	156.7
Acipenseriformes	Acipenseridae	Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*	N/A	

[a] Normalized to pH 7 (USEPA 2013).
N/A: not available

2.1.1.2 Deriving LC_{50} to LC_5 Acute Adjustment Factor

The published acute toxicity study (Fontenot et al. 1998) used to calculate the shortnose sturgeon SMAV and the *Acipenser* GMAV (which is representative of Atlantic sturgeon) did not contain or report raw toxicity data. Because no raw acute toxicity data are available for fish species in the same order, no acute order-level TAF could not? be calculated. As a result, EPA obtained and analyzed raw concentration-response (C-R) data for all tests used to derive the acute criterion (bold values in Appendix A of USEPA [2013]) where such data were reported or could be obtained to inform the derivation of a vertebrate-level TAF and a MAF, if necessary (i.e., if the vertebrate and invertebrate-level acute TAFs differ from one another).

Raw acute toxicity data were fit to C-R models using EPA's Toxicity Relationship Analysis Program (TRAP, version 1.3a) to calculate LC_{50} and corresponding LC_5 values for 83 tests representing 34 species (18 invertebrates and 16 vertebrates). C-R models were excluded from TAF and MAF calculation if 1) models did not exhibit a unique solution and were flagged by TRAP as having inadequate partial effects; 2) models did not include observations in the region of interest which did not allow TRAP to accurately model a no-response plateau and; 3) models exhibited incongruities such as no or poor fit to key points or excessive noise in the C-R relationship. After exclusion of unacceptable or uncertain LC_{50}:LC_5 ratios, 44 ratios remained resulting in nine genus-level LC_{50}:LC_5 ratios for invertebrate species (arithmetic mean = 2.157 mg/L, variance = 0.4447 mg/L) and 11 genus-level LC_{50}:LC_5 ratios for vertebrate species (arithmetic mean = 1.440 mg/L, variance = 0.0491 mg/L). Analysis of the two arithmetic means via a two-sample t-test assuming unequal variances ($\alpha = 0.05$) indicated that the means are different *(t stat [3.088] > t critical for two tail [2.262]*). Therefore, an acute vertebrate TAF is more appropriate than an acute MAF to transform the *Acipenser* GMAV applicable to the shortnose and Atlantic sturgeon (156.7 mg/L) to an acute minimum effect threshold concentration.

Table 2-2 provides the 11 genus-level LC_{50}:LC_5 ratios used to derive the acute vertebrate TAF. Individual test ratios ranged from 1.034 to 1.925. The acute vertebrate TAF calculated as the geometric mean of all genus-level LC_{50}:LC_5 ratios is 1.426 (n = 11; see Appendix A.1 for raw toxicity test data, TRAP models and outputs for the 17 acute ammonia toxicity tests used to derive the acute vertebrate TAF; Appendix A.2 includes the raw toxicity data, TRAP models and outputs for all unacceptable and uncertain ammonia C-R models).

Table 2-2. Acute LC_{50}:LC_{5} ratios from analysis of 17 high-quality acute ammonia toxicity tests with freshwater aquatic vertebrates used to derive an acute vertebrate adjustment factor (acute vertebrate TAF) for the shortnose and Atlantic sturgeon.

(Note: the acute vertebrate TAF is the geometric mean of all available genus-level LC_{50}:LC_{5} ratios for vertebrates)**.**

Order	Family	Species	LC_{50} (mg/L)	LC_{05} (mg/L)	LC_{50}: LC_{05}	C-R Curve Label	Reference	Species-level TAF (LC_{50}:LC_{05})	Genus-level TAF (LC_{50}:LC_{05})
Salmoniformes	Salmonidae	Rainbow trout (40.0 g; resting fish), *Oncorhynchus mykiss*	202.2	105.1	1.925	Am-Acute-56	Wicks et al. 2002	1.925	1.925
Cypriniformes	Cyprinidae	Rainbow dace, *Cyprinella lutrensis*	21.14	15.04	1.406	Am-Acute-58	Hazel et al. 1979	1.387	1.387
Cypriniformes	Cyprinidae	Rainbow dace, *Cyprinella lutrensis*	7.040	5.144	1.369	Am-Acute-59	Hazel et al. 1979		
Cypriniformes	Cyprinidae	Common carp (299 mg), *Cyprinus carpio*	51.65	40.37	1.279	Am-Acute-62	Hasan and MacIntosh 1986	1.279	1.279
Cypriniformes	Cyprinidae	Rio Grande silvery minnow (3-5 d old), *Hybognathus amarus*	17.52	12.52	1.399	Am-Acute-63	Buhl 2002	1.399	1.399
Cypriniformes	Cyprinidae	Fathead minnow (0.2 g), *Pimephales promelas*	43.46	42.03	1.034	Am-Acute-69	Swigert and Spacie 1983	1.188	1.188
Cypriniformes	Cyprinidae	Fathead minnow (0.5 g), *Pimephales promelas*	42.76	31.33	1.365	Am-Acute-70	Swigert and Spacie 1983		
Cypriniformes	Catostomidae	White sucker (92 mm, 6.3 g), *Catostomus commersonii*	29.27	20.35	1.439	Am-Acute-71	Reinbold and Pescitelli 1982c	1.439	1.439
Siluriformes	Ictaluridae	Channel catfish, *Ictalurus punctatus*	32.17	21.66	1.485	Am-Acute-74	Reinbold and Pescitelli 1982d	1.485	1.485
Perciformes	Centrarchidae	Pumpkinseed (4.13-9.22 g), *Lepomis gibbosus*	10.60	6.504	1.629	Am-Acute-77	Jude 1973	1.629	1.425
Perciformes	Centrarchidae	Bluegill, *Lepomis macrochirus*	6.752	5.940	1.137	Am-Acute-80	Hazel et al. 1979	1.247	
Perciformes	Centrarchidae	Bluegill (0.9 g), *Lepomis macrochirus*	57.29	46.32	1.237	Am-Acute-83	Swigert and Spacie 1983		
Perciformes	Centrarchidae	Bluegill (1.2 g), *Lepomis macrochirus*	37.54	27.22	1.379	Am-Acute-84	Swigert and Spacie 1983		
Perciformes	Percidae	Orangethroat darter, *Etheostoma spectabile*	35.15	19.97	1.760	Am-Acute-85	Hazel et al. 1979	1.620	1.620
Perciformes	Percidae	Orangethroat darter, *Etheostoma spectabile*	8.151	5.465	1.491	Am-Acute-86	Hazel et al. 1979		
Perciformes	Cichlidae	Mozambique tilapia (juvenile), *Oreochromis mossambicus*	118.2	106.2	1.113	Am-Acute-87	Rani et al. 1998	1.113	1.113
Anura	Hylidae	Pacific tree frog (embryo), *Pseudacris regilla*	62.51	39.45	1.584	Am-Acute-89	Schuytema and Nebeker 1999a	1.584	1.584

2.1.1.3 *Calculating Sturgeon Acute Ammonia Minimum Effect Threshold*

Dividing the shortnose sturgeon LC_{50} value (156.7 mg/L; genus-level surrogate value for Atlantic sturgeon) by the acute vertebrate TAF (1.426) results in an acute ammonia minimum effect threshold concentration of 109.9 mg/L (normalized to pH 7) for both sturgeon species.

2.1.1.4 *Sturgeon: Acute Ammonia Effects Determination*

The acute ammonia CMC at pH 7 (17 mg/L), is approximately 6.5 times lower than the sturgeon acute ammonia minimum effect threshold of 109.9 mg/L. The sturgeon acute minimum effect threshold concentration, based on continuous laboratory exposures, is greater than the corresponding criterion magnitude. As a result, refined assessment and consideration of the criterion duration is not necessary. As such, the effects of approval of the freshwater acute ammonia water quality standard are extremely unlikely to occur based on the fact that the established thresholds are below levels shown to have an effect, and thus all direct acute effects to shortnose and Atlantic sturgeons are discountable.

2.1.2 Sturgeon Chronic Ammonia Effects Assessment: Freshwater

2.1.2.1 *Identifying Sturgeon Chronic Ammonia Data*

High-quality empirical chronic toxicity data within the Order Acipenseriformes are not available to serve as chronic toxicity data representative of the shortnose and Atlantic sturgeon. As a result, the shortnose sturgeon SMAV (which also represents the *Acipenser* GMAV applicable to Atlantic sturgeon) was transformed to represent a chronic toxicity value (i.e., EC_{20}) of 17.46 mg/L (Table 2-3). This representative chronic value for the two sturgeon species was calculated by dividing the acute toxicity value for shortnose sturgeon (156.7 mg/L; surrogate value for Atlantic sturgeon) by the reported vertebrate ammonia acute: chronic ratio (Vert-ACR; USEPA 2013). The Vert-ACR (8.973) is based on ACRs representing five families of freshwater fishes which range from 4.8 to 14.75 (Appendix F of USEPA 2013).

Table 2-3. Data used to calculate the chronic toxicity values (i.e., EC_{20}) representative of sturgeon chronic sensitivity to ammonia.

Order	Family	Species	SMAV (mg/L)[a]	GMAV (mg/L)[a]	VERT-ACR	GMCV (mg/L)[a]
Acipenseriformes	Acipenseridae	Shortnose sturgeon, *Acipenser brevirostrum*	156.7	156.7	8.973	17.46
Acipenseriformes	Acipenseridae	Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*	N/A			

[a] Normalized to pH 7 (USEPA 2013). N/A: not available

2.1.2.2 Deriving EC_{20} to EC_5 Chronic Adjustment Factor

High-quality chronic toxicity data were not available for the shortnose and Atlantic sturgeon or species within the Order Acipenseriformes, and therefore, no raw toxicity data are available to support the derivation of a sturgeon-specific EC_{20}:EC_5 adjustment factor at or below the order-level. As a result, EPA obtained and analyzed raw C-R data for all tests used to derive the chronic criterion (USEPA 2013 Appendix B bold values) where such data were reported or could be obtained to derive a chronic vertebrate-level TAF and a MAF, if necessary (i.e., if the vertebrate and invertebrate-level chronic TAFs differ from one another).

Raw chronic toxicity data were fit to C-R models using EPA's TRAP software to calculate EC_{20} and corresponding EC_5 values for 31 tests representing 20 species (10 invertebrate and 10 fish species). C-R models were excluded from TAF and MAF calculation if 1) models did not exhibit a unique solution and were flagged by TRAP as having inadequate partial effects; 2) models did not include observations in the region of interest which did not allow TRAP to accurately model a no-response plateau and; 3) models exhibited incongruities such as no or poor fit to key points or excessive noise in the C-R relationship. After exclusion of unacceptable or uncertain EC_{20}:EC_5 ratios for use in calculating a chronic MAF, 20 ratios remained resulting in five genus-level EC_{20}:EC_5 ratios for invertebrate species (arithmetic mean = 1.341 mg/L, variance = 0.01208 mg/L) and seven genus-level EC_{20}:EC_5 ratios for vertebrate species (arithmetic mean = 1.472 mg/L, variance = 0.01326 mg/L). Analysis of the two means via a two-sample t-test assuming unequal variances ($\alpha = 0.05$) indicated that the means are the same *(t stat [-2.004] < t critical for two tail [2.262])*. As a result, the chronic MAF was used to transform the GMCV applicable to the shortnose and Atlantic sturgeon (17.46 mg/L) to a chronic minimum effect threshold concentration.

Table 2-4 provides the 12 genus-level EC_{20}:EC_5 ratios used to derive the chronic MAF. Individual test ratios ranged from 1.183 to 1.881 (Table 2-4). The chronic MAF calculated as the geometric mean of all genus-level EC_{20}:EC_5 ratios is 1.412 (see Appendix A.3 for raw toxicity test data, TRAP models and outputs for the 20 chronic ammonia toxicity tests used to derive the chronic MAF; Appendix A.4 includes the raw toxicity data, TRAP models and outputs for all unacceptable and uncertain ammonia toxicity tests).

Table 2-4. Chronic EC_{20}:EC_5 ratios from analysis of 20 high-quality chronic ammonia toxicity tests with freshwater aquatic organisms used to derive a chronic ammonia MAF representative of the shortnose and Atlantic sturgeon.
(Note: the chronic MAF is the geometric mean of all available genus-level EC_{20}:EC_5 ratios).

Order	Family	Species	EC_{20} (mg/L)	EC_{05} (mg/L)	EC_{20}: EC_{05}	C-R Curve Label	Reference	Species-level TAF (EC_{20}:EC_{05})	Genus-level TAF (EC_{20}:EC_{05})
Veneroida	Pisidiidae	Long fingernailclam, *Musculium transversum*	6.049	4.626	1.308	Am-Chronic-4	Anderson et al. 1978	1.308	1.308
Neotaenioglossa	Hydrobiidae	Pebblesnail (1.81 mm juvenile), *Fluminicola* sp.	2.269	1.559	1.455	Am-Chronic-6	Besser 2011	1.455	1.455
Diplostraca	Daphniidae	Water flea, *Ceriodaphnia acanthina*	49.59	41.21	1.203	Am-Chronic-7	Mount 1982	1.203	1.322
Diplostraca	Daphniidae	Water flea, *Ceriodaphnia dubia*	15.57	10.36	1.503	Am-Chronic-8	Nimmo et al. 1989	1.453	
Diplostraca	Daphniidae	Water flea, *Ceriodaphnia dubia*	5.720	4.072	1.405	Am-Chronic-9	Willingham 1987		
Diplostraca	Daphniidae	Water flea, *Daphnia magna*	8.265	5.026	1.645	Am-Chronic-10	Gersich et al. 1985	1.436	1.436
Diplostraca	Daphniidae	Water flea, *Daphnia magna*	20.86	16.64	1.254	Am-Chronic-11	Reinbold and Pescitelli 1982a		
Plecoptera	Pteronarcyidae	Stonefly, *Pteronarcella badia*	133.8	113.0	1.183	Am-Chronic-13	Thurston et al. 1984b	1.183	1.183
Salmoniformes	Salmonidae	Lahontan cutthroat trout (fertilized), *Oncorhynchus clarkii henshawi*	19.32	10.83	1.784	Am-Chronic-15	Koch et al. 1980	1.784	1.497
Salmoniformes	Salmonidae	Rainbow trout, *Oncorhynchus mykiss*	8.982	7.148	1.257	Am-Chronic-16	Brinkman et al. 2009	1.257	
Esociformes	Esocidae	Northern pike (fertilized), *Esox lucius*	14.81	10.91	1.357	Am-Chronic-17	Harrahy et al. 2004	1.357	1.357
Cypriniformes	Cyprinidae	Common carp (fertilized), *Cyprinus carpio*	8.246	5.612	1.469	Am-Chronic-18	Mallet and Sims 1994	1.469	1.469
Cypriniformes	Cyprinidae	Fathead minnow (embryo-larvae), *Pimephales promelas*	4.656	3.361	1.385	Am-Chronic-19	Mayes et al. 1986	1.565	1.565
Cypriniformes	Cyprinidae	Fathead minnow (embryo-larvae), *Pimephales promelas*	7.396	5.561	1.330	Am-Chronic-20	Adelman et al. 2009		
Cypriniformes	Cyprinidae	Fathead minnow, *Pimephales promelas*	5.795	3.081	1.881	Am-Chronic-21	Swigert and Spacie 1983		
Cypriniformes	Cyprinidae	Fathead minnow, *Pimephales promelas*	1.903	1.099	1.732	Am-Chronic-22	Thurston et al. 1986		
Cypriniformes	Catostomidae	White sucker (3 d old embryo), *Catostomus commersonii*	1.296	0.783	1.656	Am-Chronic-23	Reinbold and Pescitelli 1982a	1.656	1.656
Perciformes	Centrarchidae	Bluegill, *Lepomis macrochirus*	1.855	1.402	1.323	Am-Chronic-27	Smith et al. 1984	1.323	1.323

Order	Family	Species	EC_{20} (mg/L)	EC_{05} (mg/L)	EC_{20}: EC_{05}	C-R Curve Label	Reference	Species-level TAF (EC_{20}:EC_{05})	Genus-level TAF (EC_{20}:EC_{05})
Perciformes	Centrarchidae	Smallmouth bass, *Micropterus dolomieu*	8.395	5.585	1.503	Am-Chronic-30	Broderius et al. 1985	1.440	1.440
Perciformes	Centrarchidae	Smallmouth bass, *Micropterus dolomieu*	1.610	1.168	1.379	Am-Chronic-31	Broderius et al. 1985		

2.1.2.3 Calculating Sturgeon Chronic Ammonia Minimum Effect Threshold

Dividing the estimated sturgeon EC_{20} value (17.46 mg/L) by the chronic MAF (1.412) results in a chronic minimum effect threshold concentration of 12.37 mg/L (normalized to pH 7).

2.1.2.4 Sturgeon: Chronic Ammonia Effects Determination

The chronic ammonia CCC at pH 7 (1.9 mg/L), is 6.5 times lower than the Atlantic and shortnose sturgeons chronic minimum effect threshold concentration of 12.37 mg/L. The sturgeon chronic minimum effect threshold concentration, based on continuous laboratory exposures, is greater than the corresponding criterion magnitude. As a result, refined assessment and consideration of the criterion duration is not necessary. As such, the effects of approval of the freshwater acute ammonia water quality standard are extremely unlikely to occur based on the fact that the established thresholds are below levels shown to have an effect, and thus all direct chronic effects to shortnose and Atlantic sturgeons are discountable.

2.1.3 Sturgeon Ammonia Indirect Effects Assessment: Freshwater

Aquatic life criteria are conservatively implemented in National Pollution Discharge Elimination System (NPDES) permit limits by assuming receiving streams are continually at low-flow conditions which significantly limits the probability of *in situ* pollutant concentrations reaching criteria magnitudes and durations. NPDES permit limits based on the acute ammonia criterion typically assume a receiving stream is continually at 1Q10 low-flow conditions, while the probability of these low-flow conditions occurring is exceedingly rare (i.e., 1-day average lowest flow over the course of a 10-year period). Similarly, NPDES permit limits based on the chronic ammonia criterion typically assume receiving streams are continually at 30Q10 or 30Q5 low-flow conditions (i.e., 30-day average lowest flow over the course of a 5 or 10-year period). As a result, excess dilution limits instream ammonia concentrations and drastically decreases the probability *in situ* ammonia concentrations will reach criteria magnitudes and durations. Independent of assuming low flow conditions, NPDES permits also layer on an additional level of conservatism by ensuring facilities discharge ammonia at Long Term Average concentrations (LTAs), which are based on Waste Load Allocations[2] (WLAs) set as the 99th centile of a log-normal distribution that describes effluent variability. Setting WLAs as the 99th centile of an effluent distribution ensures a 99% chance facilitates discharge ammonia at concentrations less than those that would cause receiving stream ammonia concentrations to reach criteria magnitudes under critical flow conditions (which are independent and also exceedingly rare events; USEPA 1991). Additionally, even if *in situ* exposures were to match the acute or chronic criteria magnitudes, the broad aquatic community, including sturgeon prey items, will be adequately protected because aquatic life criteria are based on the fifth centile of sensitive genera.

Shortnose and Atlantic sturgeon broadly rely on benthic invertebrates, including mussels, crustaceans, and insects as primary food sources. Freshwater unionid mussels are among the

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[2] A Waste Load Allocation (WLA) is the maximum allowable pollutant concentration in an effluent from a discharger that, after accounting for available dilution under critical low flow conditions (e.g., 1Q10, 30Q5, 30Q10), will meet an applicable water quality criterion (USEPA 1991).

most sensitive genera to acute and chronic ammonia exposures, with aquatic insects and crustaceans being relatively insensitive (USEPA 2013). The acute and chronic ammonia criteria are both primarily driven by mussel sensitivity. If ammonia concentrations in Virginia freshwater ecosystems were to occur at acute or chronic criteria magnitudes and durations (which is highly unlikely based the conservative implementation of criteria in NPDES permit limits), a small portion of individuals in the most sensitive mussel populations may experience short-term effects. Further, if ammonia were to exist at criteria concentrations indefinitely in Virginia freshwaters (which is not the intent of the action considering the full definition of criteria include magnitude, duration, and frequency), shortnose sturgeon and Atlantic sturgeon would not be indirectly affected because only a small portion of mussels would experience effects and sturgeon do not rely exclusively on mussels as a food source, with additional sturgeon food sources (e.g., insects and benthic worms) remaining tolerant to acute and chronic ammonia exposures (USEPA 2013). As such, the effects of approval of the freshwater acute and chronic ammonia water quality standard are too small to be detected and thus any indirect chronic or acute effects to shortnose and Atlantic sturgeons are insignificant.

3 Cadmium Effects Assessment

3.1 Sturgeon: Shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus oxyrinchus*)

3.1.1 Sturgeon Acute Cadmium Effects Assessment: Freshwater

3.1.1.1 Identifying Sturgeon Acute Cadmium Data

High quality species-level acute data were not available for either sturgeon species. Therefore, genus-level acute toxicity data are used to represent the sensitivity of shortnose and Atlantic sturgeons to acute cadmium exposures. The GMAV is based on a single SMAV for the white sturgeon (Table 3-1). The SMAV is composed of a single, non-definitive LC_{50} value (<33.78 µg/L, normalized to a total hardness of 100 mg/L as $CaCO_3$) from a test with a sensitive life stage (Calfee et al. 2014). The non-definitive LC_{50} value introduces uncertainty in the GMAV estimate and it is reasonable to consider how much lower a definitive LC_{50} value would be compared to the non-definitive LC_{50} estimate. EPA was able to independently evaluate the C-R curve used to calculate the white sturgeon-based GMAV (which is representative of shortnose and Atlantic sturgeon) from Calfee et al. (2014). Acute toxicity data were provided in Table A-2 of the parent USGS report (Ingersoll and Mebane 2014), which provided sufficient supplemental information to create the C-R curve for the test (see Cd-Acute-93 in Appendix B.2). The TRAP model generated from the data is unacceptable for deriving an LC_{50} to LC_5 ratio due to no effect within the area of concern, especially at low-levels (i.e., 5%), but provides a definitive LC_{50} value of 23.14 total cadmium (normalized to a hardness of 100 mg/L). The LC_{50} value calculated from Ingersoll and Mebane (2014; see Cd-Acute-93 in Appendix B.2) contains some underlying uncertainty because the lowest test concentrations (beside the negative control group) resulted in 70% mortality.

Nevertheless, use of the definitive LC_{50} (23.14 total cadmium, normalized to a hardness of 100 mg/L) for white sturgeon as the *Acipenser* GMAV may be appropriate for several reasons. First, Calfee et al. (2014) tested six different sturgeon life stages ranging from 2 to 89 days post hatch (dph) and reported normalized (hardness = 100 mg/L) LC_{50} values ranging from >11.65 to >355.0 µg total Cd/L. Of the six life stages tested, EPA concluded white sturgeon tested at 61 dph were the most sensitive to acute cadmium toxicity, and the non-definitive LC_{50} value (reported by Calfee et al. [2014] as <33.78 µg/L; hardness = 100 mg/L; total cadmium) for white sturgeon of this age was among the most sensitive of LC_{50} values available for sturgeon. Second, Calfee et al. (2014) comparatively assessed sturgeon and rainbow trout sensitivities to cadmium and concluded, "*Rainbow trout were more sensitive to cadmium exposure than white sturgeon for all life stages tested.*" Calfee et al. (2014) further states, "*Rainbow trout in the present study were especially sensitive to cadmium relative to other species*," which is consistent with salmonid genera ranking among the most sensitive in the species sensitivity distribution (SSD) used to derive the acute cadmium criterion (USEPA 2016). The acute cadmium criterion is based on the fifth centile of sensitive genera and is largely influenced by salmonid sensitivity. Because Calfee et al. (2014) determined salmonids are more sensitive to cadmium than sturgeon, and the acute criterion is based on salmonid sensitivity, the acute criterion is expected to be protective of sturgeon and the use of a definitive acute toxicity estimate that contains some underlying uncertainty given the lack of low-level effects in the C-R curve (see Cd-Acute-93 in Appendix B.2) will not result in spurious conclusions.

Table 3-1. Data used to calculate the *Acipenser* GMAV representative of shortnose and Atlantic sturgeon acute sensitivity to cadmium.

Order	Family	Species	SMAV (µg/L)[a]	GMAV (µg/L)[a]
Acipenseriformes	Acipenseridae	White sturgeon, *Acipenser transmontanus*	23.24	23.14
Acipenseriformes	Acipenseridae	Shortnose sturgeon, *Acipenser brevirostrum*	N/A	
Acipenseriformes	Acipenseridae	Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*	N/A	

[a] Normalized to a hardness of 100 mg/L as $CaCO_3$ (USEPA 2016).
N/A: not available

3.1.1.2 Deriving LC_{50} to LC_5 Acute Adjustment Factor

As previously described, the TRAP model (see Cd-Acute-93 in Appendix B.2) produced by analysis of the data from the acute toxicity test with 61 dph white sturgeon (Calfee et al. 2014) is unacceptable for use as a *Acipenser*-specific (genus-level) taxonomic adjustment factor because of a lack of low-level effects resulting in no responses in the area of interest along the C-R curves (i.e., 5% - 50%). No other acute toxicity tests with C-R data are available for the Order Acipenseriformes. As a result, EPA obtained and analyzed raw C-R data for all tests used to derive the acute cadmium criterion (underlined values in Appendix A of USEPA 2016; Table 3-2) where such data were reported or could be obtained to derive an acute vertebrate TAF or acute MAF, if necessary (i.e., if the vertebrate and invertebrate-level acute TAFs differ from one another).

Raw acute toxicity data were fit to C-R models using EPA's TRAP software to calculate LC_{50} and corresponding LC_5 values for 69 tests representing 28 species (18 invertebrate and 10 vertebrates, including an amphibian). C-R models were excluded from TAF and MAF calculation if 1) models did not exhibit a unique solution and were flagged by TRAP as having inadequate partial effects; 2) models did not include observations in the region of interest which did not allow TRAP to accurately model a no-response plateau and; 3) models exhibited incongruities such as no or poor fit to key points or excessive noise in the C-R relationship. After exclusion of these unacceptable or uncertain LC_{50}:LC_5 ratios for use in calculating an acute MAF, 35 ratios remained resulting in seven genus-level LC_{50}:LC_5 ratios for invertebrate species (arithmetic mean = 2.857 µg/L, variance = 2.186 µg/L) and six genus-level LC_{50}:LC_5 ratios for vertebrate species (arithmetic mean = 2.106 µg/L, variance = 0.2589 µg/L). Analysis of the two arithmetic means via a two-sample t-test assuming unequal variances ($\alpha = 0.05$) indicated the means are the same *(t stat [1.259] < t critical for two tail [2.306]*). As a result, the acute MAF was used to transform the *Acipenser* GMAV representative of shortnose and Atlantic sturgeon (<33.78 µg/L) to an acute minimum effect threshold concentration.

Table 3-2 provides the 13 genus-level LC_{50}:LC_5 ratios used to derive the cadmium acute MAF. The acute MAF calculated as the geometric mean of all genus-level LC_{50}:LC_5 ratios is 2.310 (see Appendix B.3 for raw toxicity test data, TRAP models and outputs for the 35 acute cadmium toxicity tests used to derive the acute MAF; Appendix B.4 includes the raw toxicity data, TRAP models and output for all unacceptable and uncertain cadmium toxicity tests).

Table 3-2. Acute LC_{50}:LC_5 ratios from analysis of 35 high-quality acute cadmium toxicity tests with freshwater aquatic organisms used to derive an acute mean adjustment factor (MAF) for the shortnose and Atlantic sturgeons.

Order	Family	Species	LC_{50} (µg/L)	LC_{05} (µg/L)	LC_{50}: LC_{05}	C-R Curve Label	Reference	Species-level TAF (LC_{50}:LC_{05})	Genus-level TAF (LC_{50}:LC_{05})
Tubificida	Naididae	Tubificid worm, *Tubifex tubifex*	56,141	27,732	2.024	Cd-Acute-2	Rathore and Khangarot 2002	2.278	2.278
Tubificida	Naididae	Tubificid worm, *Tubifex tubifex*	26,650	10,289	2.590	Cd-Acute-5	Rathore and Khangarot 2002		
Tubificida	Naididae	Tubificid worm, *Tubifex tubifex*	423.3	299.5	1.414	Cd-Acute-6	Rathore and Khangarot 2003		
Tubificida	Naididae	Tubificid worm, *Tubifex tubifex*	6,463	1,778	3.634	Cd-Acute-8	Rathore and Khangarot 2003		
Basommatophora	Lymnaeidae	Pond snail (juvenile, stage II, 9 wk), *Lymnaea stagnalis*	1,735	718.0	2.416	Cd-Acute-9	Coeurdassier et al. 2004	2.016	2.016
Basommatophora	Lymnaeidae	Pond snail (adult, 20 wk), *Lymnaea stagnalis*	1,670	1,051	1.590	Cd-Acute-10	Coeurdassier et al. 2004		
Basommatophora	Lymnaeidae	Pond snail (juvenile, 25 mm), *Lymnaea stagnalis*	350.8	164.3	2.135	Cd-Acute-12	Pais 2012		
Basommatophora	Physidae	Snail (adult, 3.3-15 mm), *Physa acuta*	1,619	1,375	1.177	Cd-Acute-14	Woodard 2005	1.177	1.177
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	30.54	13.76	2.220	Cd-Acute-17	Shaw et al. 2006	2.220	2.220
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Daphnia magna*	170.8	13.67	12.49	Cd-Acute-19	Shaw et al. 2006	4.580	4.580
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Daphnia magna*	517.6	308.3	1.679	Cd-Acute-22	Perez and Beiras 2010		
Decapoda	Cambaridae	Crayfish (adult), *Orconectes virilis*	6,007	2,427	2.475	Cd-Acute-30	Mirenda 1986	2.475	2.475
Ephemeroptera	Heptageniidae	Mayfly (nymph), *Rhithrogena hageni*	10,924	2,080	5.251	Cd-Acute-35	Brinkman and Vieira 2007; Brinkman and Johnston 2008	5.251	5.251
Salmoniformes	Salmonidae	Rainbow trout (8.8 g), *Oncorhynchus mykiss*	3.055	1.759	1.737	Cd-Acute-47	Phipps and Holcombe 1985	2.067	2.067
Salmoniformes	Salmonidae	Rainbow trout	1.682	0.5849	2.876	Cd-Acute-48	Stubblefield 1990		

Order	Family	Species	LC_{50} (µg/L)	LC_{05} (µg/L)	LC_{50}: LC_{05}	C-R Curve Label	Reference	Species-level TAF (LC_{50}:LC_{05})	Genus-level TAF (LC_{50}:LC_{05})
		(juvenile, 18.3 g), *Oncorhynchus mykiss*							
Salmoniformes	Salmonidae	Rainbow trout (36 g), *Oncorhynchus mykiss*	2.679	1.683	1.591	Cd-Acute-49	Davies et al. 1993		
Salmoniformes	Salmonidae	Rainbow trout (36 g), *Oncorhynchus mykiss*	7.052	3.007	2.345	Cd-Acute-53	Davies et al. 1993		
Salmoniformes	Salmonidae	Rainbow trout (fry, 1.0 g), *Oncorhynchus mykiss*	2.773	1.726	1.606	Cd-Acute-55	Davies and Brinkman 1994b		
Salmoniformes	Salmonidae	Rainbow trout (fry, 1.0 g), *Oncorhynchus mykiss*	2.152	1.116	1.928	Cd-Acute-58	Davies and Brinkman 1994b		
Salmoniformes	Salmonidae	Rainbow trout (fry, 2.5 g), *Oncorhynchus mykiss*	10.14	5.298	1.914	Cd-Acute-60	Davies and Brinkman 1994b		
Salmoniformes	Salmonidae	Rainbow trout (263 mg), *Oncorhynchus mykiss*	0.6500	0.3493	1.861	Cd-Acute-61	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Rainbow trout (659 mg), *Oncorhynchus mykiss*	0.4134	0.2108	1.961	Cd-Acute-62	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Rainbow trout (1,150 mg), *Oncorhynchus mykiss*	0.4634	0.2174	2.132	Cd-Acute-63	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Rainbow trout (1,130 mg), *Oncorhynchus mykiss*	0.3528	0.2237	1.577	Cd-Acute-64	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Rainbow trout (299 mg), *Oncorhynchus mykiss*	1.210	0.3198	3.784	Cd-Acute-65	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Rainbow trout (289 mg), *Oncorhynchus mykiss*	2.548	1.042	2.445	Cd-Acute-66	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Brown trout (fingerling, 22.4 g), *Salmo trutta*	2.732	0.9770	2.797	Cd-Acute-76	Stubblefield 1990	2.797	2.797
Salmoniformes	Salmonidae	Bull trout (0.200 g), *Salvelinus confluentus*	0.9828	0.4530	2.169	Cd-Acute-79	Stratus Consulting 1999	2.402	2.402
Salmoniformes	Salmonidae	Bull trout (0.221 g), *Salvelinus confluentus*	0.9994	0.3656	2.734	Cd-Acute-80	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Bull trout (0.0842 g), *Salvelinus confluentus*	3.200	1.254	2.552	Cd-Acute-82	Stratus Consulting 1999		
Salmoniformes	Salmonidae	Bull trout (0.0727 g), *Salvelinus confluentus*	5.942	2.700	2.201	Cd-Acute-83	Stratus Consulting 1999		

Order	Family	Species	LC_{50} (µg/L)	LC_{05} (µg/L)	LC_{50}: LC_{05}	C-R Curve Label	Reference	Species-level TAF (LC_{50}:LC_{05})	Genus-level TAF (LC_{50}:LC_{05})
Cypriniformes	Cyprinidae	Red shiner (adult, 0.80-2.0 g), *Cyprinella lutrensis*	6,731	4,903	1.373	Cd-Acute-85	Carrier 1987; Carrier and Beitinger 1988a	1.373	1.373
Cypriniformes	Cyprinidae	Zebrafish (adult), *Danio rerio*	15,631	8,012	1.951	Cd-Acute-86	Vergauwen 2012; Vergauwen et al. 2013	1.710	1.710
Cypriniformes	Cyprinidae	Zebrafish (adult), *Danio rerio*	12,384	8,263	1.499	Cd-Acute-87	Vergauwen 2012; Vergauwen et al. 2013		
Anura	Pipidae	African clawed frog, *Xenopus laevis*	3,314	1,447	2.290	Cd-Acute-101	Sunderman et al. 1991	2.290	2.290

3.1.1.3 Calculating Sturgeon Acute Cadmium Minimum Effect Threshold

Dividing the white sturgeon LC_{50} value (23.14 µg/L; genus-level surrogate value for shortnose and Atlantic sturgeon) by the acute MAF (2.310) results in an acute cadmium minimum effect threshold concentration of 10.02 µg/L (normalized to a hardness of 100 mg/L as $CaCO_3$) for both sturgeon species.

3.1.1.4 Sturgeon: Acute Cadmium Effects Determination

The acute cadmium CMC at hardness of 100 mg/L as $CaCO_3$ (1.9 µg/L total Cd), is over five times lower than the sturgeon acute cadmium minimum effect threshold of 10.02 µg/L total cadmium. The sturgeon acute minimum effect threshold concentration, based on continuous laboratory exposures, is greater than the corresponding criterion magnitude. As a result, refined assessment and consideration of the criterion duration is not necessary. As such, the effects of approval of the freshwater acute cadmium water quality standard are extremely unlikely to occur based on the fact that the established thresholds are below levels shown to have an effect, and thus all direct acute effects to shortnose and Atlantic sturgeons are discountable.

3.1.2 Sturgeon Chronic Cadmium Effects Assessment: Freshwater

3.1.2.1 Identifying Sturgeon Chronic Cadmium Data

High-quality empirical chronic toxicity data within the Order Acipenseriformes are not available to serve as chronic toxicity data representative of the shortnose and Atlantic sturgeon. As a result, the *Acipenser* GMAV (23.14 µg/L; Table 3-1) was transformed to represent a chronic toxicity value (i.e., EC_{20}) of 2.79 µg/L (Table 3-3). This representative chronic value for the two sturgeon was calculated by dividing the acute toxicity value for white sturgeon (23.14 µg/L; representative of shortnose and Atlantic sturgeon) by the Final Acute-to-Chronic Ratio (FACR) reported in the cadmium criteria document (USEPA 2016). Unlike the ammonia effects assessment that relied on an ACR calculated (geometric mean) from all available vertebrate ACRs, the FACR was used here because ACRs reported in USEPA (2016) vary by more than a factor of ten, even when only considering ACRs from vertebrate species. Additionally, USEPA (2016), states *"... none of the four methods suggested in the 1985 Guidelines (Stephan et al. 1985) for calculating the FACR are appropriate for cadmium... Thus, an alternate approach was used to determine the FACR. The recommended FACR of 8.291 was obtained from the geometric mean of seven genus-level ACRs... Americamysis (7.070), Ceriodaphnia (19.84), Daphnia (23.90), Cottus (11.22), Oncorhynchus (2.0), Salmo (2.0) and Pimephales (17.90).*" The FACR is intended to broadly relate a species acute effect concentration to an estimated chronic effect concentration (EC_{20}).

Table 3-3. Data used to calculate the GMCV representative of sturgeon sensitivity to cadmium.

Order	Family	Species	SMAV (µg/L)[a]	GMAV (µg/L)[a]	FACR	GMCV (µg/L)[a]
Acipenseriformes	Acipenseridae	White sturgeon, *Acipenser transmontanus*	23.14	23.14	8.291	2.79
Acipenseriformes	Acipenseridae	Shortnose sturgeon, *Acipenser brevirostrum*	N/A			
Acipenseriformes	Acipenseridae	Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*	N/A			

[a] Normalized to a hardness of 100 mg/L as $CaCO_3$ (USEPA 2016).
N/A: not available

3.1.2.2 Deriving EC_{20} to EC_5 Chronic Adjustment Factor

High-quality chronic toxicity data were not available for the shortnose and Atlantic sturgeon or surrogate species within the Order Acipenseriformes, and therefore, no raw toxicity data are available to support the derivation of a sturgeon-specific EC_{20}:EC_5 adjustment factor at or below the order-level. As a result, EPA obtained and analyzed raw C-R data for all tests used to derive the chronic criterion (USEPA 2016 Appendix C underlined values) where such data were reported or could be obtained to derive a chronic vertebrate TAF or chronic MAF, if necessary (i.e., if the vertebrate and invertebrate-level chronic TAFs differ from one another).

Raw chronic toxicity data were fit to C-R models using EPA's TRAP software to calculate EC_{20} and corresponding EC_5 values for 40 tests representing 17 species (8 invertebrate and 9 fish species). C-R models were excluded from TAF and MAF calculation if 1) models did not exhibit a unique solution and were flagged by TRAP as having inadequate partial effects; 2) models did not include observations in the region of interest which did not allow TRAP to accurately model a no-response plateau and; 3) models exhibited incongruities such as no or poor fit to key points or excessive noise in the C-R relationship. After exclusion of unacceptable or uncertain EC_{20}:EC_5 ratios, 13 ratios remained resulting in three genus-level EC_{20}:EC_5 ratios for invertebrate species (arithmetic mean = 1.779 µg/L, variance = 0.07706 µg/L) and four genus-level EC_{20}:EC_5 ratios for vertebrate species (arithmetic mean = 1.332 µg/L, variance = 0.008872 µg/L). Analysis of the two means via a two-sample t-test assuming unequal variances ($\alpha = 0.05$) indicated that the means are the same (*t stat [2.677] < t critical for two tail [4.303]*). As a result, the chronic MAF was used to transform the GMCV applicable to the shortnose and Atlantic sturgeon (<4.074 µg/L) to a chronic minimum effect threshold concentration.

Table 3-4 provides the seven genus-level EC_{20}:EC_5 ratios used to derive the chronic MAF. Individual test ratios ranged from 1.229 to 2.097. The chronic MAF calculated as the geometric mean of all genus-level EC_{20}:EC_5 ratios is 1.502 (see Appendix B.3 for raw toxicity test data, TRAP models and outputs for the 13 chronic cadmium toxicity tests used to derive the chronic MAF; Appendix B.4 includes the raw toxicity data, TRAP models and outputs for all unacceptable and uncertain cadmium toxicity tests).

Table 3-4. Chronic EC_{20}:EC_5 ratios from analysis of 13 high-quality chronic cadmium toxicity tests with freshwater aquatic organisms used to derive a chronic cadmium MAF representative of the shortnose and Atlantic sturgeon.

Order	Family	Species	EC_{20} (µg/L)	EC_{05} (µg/L)	EC_{20}: EC_{05}	C-R Curve Label	Reference	Species-level TAF (EC_{20}:EC_{05})	Genus-level TAF (EC_{20}:EC_{05})
N/A[a]	Aeolosomatidae	Oligochaete, *Aeolosoma headleyi*	57.35	27.35	2.097	Cd-Chronic-1	Niederlehner et al. 1984	2.097	2.097
Diplostraca	Daphniidae	Cladoceran, *Ceriodaphnia dubia*	4.940	3.352	1.474	Cd-Chronic-12	Southwest Texas State University 2000	1.584	1.584
Diplostraca	Daphniidae	Cladoceran, *Ceriodaphnia dubia*	5.505	3.235	1.702	Cd-Chronic-13	Southwest Texas State University 2000		
Diplostraca	Daphniidae	Cladoceran, *Daphnia magna*	0.2118	0.1059	2.000	Cd-Chronic-15	Chapman et al. Manuscript	1.657	1.657
Diplostraca	Daphniidae	Cladoceran, *Daphnia magna*	6.166	4.489	1.374	Cd-Chronic-17	Bodar et al. 1988b		
Salmoniformes	Salmonidae	Rio Grande cutthroat trout *Oncorhynchus clarkii virginalis*	2.354	1.659	1.419	Cd-Chronic-24	Brinkman 2012	1.419	1.365
Salmoniformes	Salmonidae	Rainbow trout, *Oncorhynchus mykiss*	2.283	1.774	1.287	Cd-Chronic-26	Davies et al. 1993	1.312	
Salmoniformes	Salmonidae	Rainbow trout, *Oncorhynchus mykiss*	4.956	3.719	1.333	Cd-Chronic-27	Davies et al. 1993		
Salmoniformes	Salmonidae	Rainbow trout, *Oncorhynchus mykiss*	4.315	3.272	1.319	Cd-Chronic-28	Davies et al. 1993		
Salmoniformes	Salmonidae	Brown trout, *Salmo trutta*	5.187	4.221	1.229	Cd-Chronic-42	Brinkman and Hansen 2004a; 2007	1.229	1.229
Cyprinodontiformes	Cyprinodontidae	Flagfish, *Jordanella floridae*	5.018	3.470	1.446	Cd-Chronic-48	Spehar 1976	1.446	1.446
Scorpaeniformes	Cottidae	Mottled sculpin, *Cottus bairdii*	1.762	1.329	1.326	Cd-Chronic-52	Besser et al. 2007	1.289	1.289
Scorpaeniformes	Cottidae	Mottled sculpin, *Cottus bairdii*	1.285	1.026	1.252	Cd-Chronic-53	Besser et al. 2007		

[a] N/A; not available, no order listed in the Integrated Taxonomic Information System (www.itis.gov) for the species.

3.1.2.3 Calculating Sturgeon Chronic Cadmium Minimum Effect Threshold

Dividing the estimated sturgeon EC_{20} value (2.79 µg/L) by the chronic MAF (1.502) results in chronic minimum effect threshold concentration of 1.86 µg/L (normalized to a hardness of 100 mg/L as $CaCO_3$) for both sturgeon species.

3.1.2.4 Sturgeon: Chronic Cadmium Effects Determination

The cadmium CCC of 0.79 µg/L total Cd (at a hardness of 100 mg/L as $CaCO_3$), is 2.3 times lower than the sturgeon chronic cadmium minimum effect threshold concentration of 1.86 µg/L total cadmium, suggest sturgeon are tolerant to chronic cadmium exposures.

The threshold concentration is based on an acute value calculated from a relatively uncertain C-R curve (e.g., lowest test concentrations [excluding control groups] resulted in 70% mortality; see Cd-Acute-93 in Appendix B.2; see section 3.1.1.1). When deriving criteria and developing effects assessments, EPA relies on the most relevant and high-quality data possible to inform scientifically-sound conclusions. In certain cases, however, EPA may consider lower-quality toxicity data as supportive auxiliary information. Appendix H of the Cadmium 304(a) Aquatic Life Criteria document (USEPA 2016) contains "Other Toxicity Data" for freshwater species and consists of studies that do not meet the rigorous data quality, type, and documentation requirements specified in the 1985 Guidelines (Stephen et al. 1985), yet may contain quality portions that may be considered as supportive auxiliary data.

Appendix H of USEPA (2016) contains four white sturgeon (genus-level surrogate for shortnose and Atlantic sturgeons) chronic toxicity assays obtained from two different publications (Vardy et al. 2011; Wang et al. 2014a). Data from Vardy et al. (2011) are not further considered here because the two chronic toxicity assays reported by Vardy et al. (2011) did not include negative control groups, representing a critical flaw in the underlying study design. Chronic toxicity data for the white sturgeon reported by Wang et al. (2014a) did not contain critical flaws in the study design but were excluded from criteria derivation because reported exposure durations were either too short (EC_{20} < 11 µg/L; hardness = 100 mg/L; endpoint = survival) or were started too late in the sturgeon life stage to constitute an appropriate early life stage test (ELS test; EC_{20} = 3.2 µg/L; hardness = 100 mg/L; endpoint = biomass). Calfee et al. (2014), EPA (2016), and Ingersoll and Mebane (2014) report sturgeon sensitivity to acute cadmium exposures generally increases with increasing days post hatch (up until sturgeon reach a certain age around 72 dph), suggesting it may be appropriate to further consider the EC_{20} (3.2 µg/L) that was excluded from criteria derivation because exposures were started to late to constitute an ELS test. Therefore, EPA divided the EC_{20} value of 3.2 µg/L (Wang et al. 2014a) by the chronic MAF (chronic MAF = 1.502; see Section 3.1.2.2) to calculate a secondary chronic low effect threshold of 2.13 µg/L (hardness = 100 mg/L). The secondary chronic low effect threshold of 2.13 µg/L is similar to the primary chronic low effect threshold of 1.86 µg/L and provides an additional line of evidence to support that sturgeon are tolerant to cadmium at the chronic criterion magnitude (CCC = 0.79 µg/L; hardness = 100 mg/L).

The sturgeon chronic minimum effect threshold concentration, based on continuous laboratory exposures, is greater than the corresponding criterion magnitude. Furthermore, supportive data from less-certain chronic toxicity studies were used to calculate a secondary chronic low effect threshold that is also greater than the corresponding criterion magnitude, providing an additional line of evidence to suggest sturgeon are relatively tolerant to chronic cadmium exposures. As a result, refined assessment and consideration of the criterion duration is not necessary. As such, the effects of approval of the freshwater chronic cadmium water quality standard are extremely unlikely to occur based on the fact that the established thresholds are below levels shown to have an effect, and thus all direct chronic effects to shortnose and Atlantic sturgeons are discountable.

3.1.3 Sturgeon Acute and Chronic Cadmium Effects Assessment: Estuarine/Marine

Acceptable acute saltwater toxicity data for cadmium criteria derivation were available for 94 different estuarine/marine species representing 79 genera, while only two chronic studies conducted on mysid species were available for consideration in deriving the chronic criterion for cadmium in estuarine/marine water. Therefore, the acute estuarine/marine cadmium final acute value (FAV) was transformed by a FACR to derive the chronic criterion magnitude for cadmium in estuarine/marine waters. The four most sensitive genera to acute cadmium exposures were all invertebrates, suggesting vertebrate species, including sturgeon, are relatively insensitive to cadmium toxicity in estuarine/marine waters.

Empirical acute and chronic toxicity data for saltwater life stages of shortnose and Atlantic and sturgeons, or appropriate surrogate species (i.e., members of the Order Acipenseriformes), are not available. Freshwater data, however, suggest sturgeon are most sensitive to cadmium exposures as young fry in freshwaters, and quickly becoming relatively insensitive as they age and migrate toward estuarine and marine waters. USEPA (2016) states, "*Several life stages of the white sturgeon, Acipenser transmontanus, were exposed in flow-through measured exposures by Calfee et al. (2014) and Wang et al. (2014a). The most sensitive life stage were the 61 day post hatch fish with a non-definitive normalized acute value of <33.78 µg/L total cadmium. However, all other life stages were much less sensitive...*" Calfee et al. (2014) reported normalized (hardness = 100 mg/L) white sturgeon LC_{50} values increasing from <33.78 µg/L at 61 days post hatch (dph) to >150.9 µg/L total cadmium at 72 dph, with white sturgeon becoming increasingly tolerant to cadmium at 89 dph with an LC_{50} exceeding 278.6 µg/L. Therefore, Atlantic and shortnose sturgeon life stages occurring in estuarine and marine environments are expected to be relatively insensitive to cadmium.

Because estuarine/marine acute and chronic cadmium criteria are based the fifth centile of sensitive genera (i.e., invertebrates) and designed to protect sensitive genera, the criteria will also protect less sensitive taxa, including sturgeon. Because of their tolerance to the cadmium levels proposed for approval, any effects of the approval of the acute and chronic cadmium estuarine/marine water quality criteria are extremely unlikely to occur and are discountable.

3.1.4 Sturgeon Cadmium Indirect Effects Assessment: Freshwater and Estuarine/Marine

Aquatic life criteria are based on the fifth centile of sensitive genera to protect aquatic communities, including listed species and their prey items. Further, aquatic life criteria are conservatively implemented in National Pollution Discharge Elimination System (NPDES) permit limits by assuming receiving streams are continually at low-flow conditions which significantly limits the probability of *in situ* pollutant concentrations reaching criteria magnitudes and durations. NPDES permit limits based on the acute cadmium criterion typically assume a receiving stream is continually at 1Q10 low-flow conditions, while the probability of these low-flow conditions occurring is exceedingly rare (i.e., 1-day average lowest flow over the course of a 10-year period). Similarly, NPDES permit limits based on the chronic cadmium criterion typically assume receiving streams are continually at 7Q10 low-flow conditions (i.e., 7-day average lowest flow over the course of a 10-year period). As a result, excess dilution limits instream cadmium concentrations and drastically decreases the probability *in situ* cadmium concentrations will reach criteria magnitudes and durations. Independent of assuming low flow conditions, NPDES permits also layer on an additional level of conservatism by ensuring facilities discharge cadmium at Long Term Average concentrations (LTAs), which are based on Waste Load Allocations[2] (WLAs) set as the 99th centile of a log-normal distribution that describes effluent variability. Setting WLAs as the 99th centile of an effluent distribution ensures a 99% chance facilitates discharge cadmium at concentrations less than those that would cause receiving stream cadmium concentrations to reach criteria magnitudes under critical flow conditions (which are independent and also exceedingly rare events; USEPA 1991). Additionally, even if *in situ* exposures were to match the acute or chronic criteria magnitudes, the broad aquatic community, including sturgeon prey items, will be adequately protected because aquatic life criteria are based on the fifth centile of sensitive genera.

Atlantic and shortnose sturgeon broadly rely on benthic invertebrates, including mussels, crustaceans, and insects as primary food sources, all of which are relatively insensitive to acute and chronic cadmium exposures in freshwaters. For example, the most sensitive genera to acute cadmium exposures includes salmonids (*Oncorhynchus*, *Salvelinus* and *Salmo*), sculpin (*Cottus*), and striped bass (*Morone*; Table 7 of USEPA 2016), with pelagic crustaceans (*Hyalella* and *Ceriodaphnia*), sculpin (*Cottus*), and a midge (*Chironomu*s) comprising the four most-sensitive genera to chronic exposures in freshwater (Table 9 of USEPA 2016). In estuarine/marine water, the most sensitive species to acute cadmium exposures (and by extension, chronic cadmium exposure given limited chronic estuarine/marine data) include two mysid genera (*Neomysis* and *Americamysis*), a copepod (*Tigriopus*), and a jellyfish (*Aurelia*). Remaining acute estuarine/marine cadmium toxicity data indicate primary sturgeon prey items, including gastropods, bivalves, oligochaetes, and benthic crustaceans, are also insensitive to acute and chronic cadmium exposures in marine/estuarine environments (Table 10 of USEPA 2016). Even if certain components of shortnose and Atlantic sturgeon diets were among the most-sensitive genera, the sturgeon would not experience any appreciable indirect effects because they are broad opportunistic feeders. Sturgeon consume a wide range of inveterate taxa, which are adequately protected by the cadmium criteria, considering criteria are typically based on the fifth centile of sensitive genera and implemented under conservative exposure conditions.

EPA approval of the freshwater (acute and chronic) and estuarine/marine cadmium criteria (acute and chronic) as Virginia water quality standards is Not Likely to Adversely Affect (NLAA) Atlantic and shortnose sturgeon through indirect effects because: 1) criteria are implemented conservatively; 2) sturgeon prey items are relatively insensitive to cadmium compared to those genera that drive the criteria magnitudes; and 3) sturgeon are not specialized feeders relying on a specific prey item that may be affected by cadmium exposures. As such, the effects of approval of the freshwater acute and chronic cadmium water quality standard are too small to be detected and thus any indirect chronic or acute effects to shortnose and Atlantic sturgeons are insignificant.

3.2 Sea Turtles: Green (*Chelonia mydas*), Leatherback (*Dermochelys coriacea*), Hawksbill (*Eretmochelys imbricate*), Kemp's Ridley (*Lepidochelys kempii*), and Loggerhead (*Caretta caretta*)

3.2.1 Sea Turtle Acute and Chronic Cadmium Effects Assessment: Estuarine/Marine

Sea turtles are expected to experience no effects associated with approval to the freshwater acute and chronic cadmium criteria due to no co-occurrence of sea turtles and cadmium in Virginia freshwaters. Given the immense dilution associated with marine environments, co-occurrence of sea turtles and cadmium at exposure concentrations and durations associated with the acute and chronic estuarine/marine criteria is also unlikely. For example, NOAA fisheries (NMFS 2012) previously assessed the protectiveness of earlier, less stringent, cadmium criteria (USEPA 2001; CMC = 40.28 µg/L; CCC = 8.9 µg/L; hardness = 100 mg/L) for estuarine/marine waters in Oregon and concluded:

> "*the proposed action is not likely to adversely affect (NLAA)… loggerhead sea turtles, green sea turtles, leatherback sea turtles, or Olive Ridley sea turtles. The above identified marine…sea turtle species are distributed in coastal areas and may be exposed to effects related to the proposed numeric criteria. Similar to Southern Resident killer whales, effects would be indirect and would include reduced prey availability, reduced prey quality, and potential accumulation in the individuals exposed. However, the occurrence of the subject ESA-listed sea turtles and large whales would be rare, infrequent, and transitory in the action area.*"

Moreover, juveniles of all turtle species occurring within Virginia waters forage and mature for several years after hatching in open ocean habitats far from shore (see section 3.2.2), limiting exposure to early life stages, which tend to be the most-sensitive life stage of many taxa to pollutant exposures. Listed sea turtles in estuarine/marine waters of Virginia are not expected to be exposed to cadmium at criteria magnitudes and durations, especially as early life stages. As a result, the effects of approval of the acute and chronic estuarine/marine cadmium criteria on the green sea turtle, leatherback turtle, Kemp's ridley turtle, and loggerhead turtle are extremely unlikely to occur, and discountable.

3.2.2 Sea Turtle Cadmium Indirect Effects Assessment: Freshwater and Estuarine/Marine

Broadly, all listed sea turtles occurring within the action area share fundamentally similar life cycles and diets. After hatching, green sea turtles swim to offshore areas where they reside for several years feeding close to the surface on a variety of pelagic plants and animals. As adults, green sea turtles travel to foraging grounds closer to shore, feeding primarily on algae and grasses in benthic habitats. As adults they are almost exclusively herbivorous, primarily consuming seagrasses and algae. Leatherback turtles spend the majority of their life in open ocean, except when females must migrate to near shore habitat to lay eggs on sandy, tropical beaches. After nesting season, leatherbacks migrate from tropical waters to more temperate latitudes, which support high densities of jellyfish prey in the summer. Juvenile hawkshill turtles are initially pelagic- sheltering on floating mats of algae and foraging on the surface. As adults, they enter coastal foraging areas near reefs where they feed primarily on algae, sponges, and other invertebrates associated with coral reef environments (NOAA 2017).

After hatching, Kemp's ridley turtles enter water and swim quickly from near shore to escape predators, remaining in open ocean for about two years then return to coastal zones as sub-adults and adults where they forage for prey, including crabs, fish, jellyfish, and mollusks, in muddy or sandy bottom substrates. Loggerhead hatchlings move from their nest to the surf and are swept through the surf zone, and continue swimming away from land for up to several days. Post-hatchling loggerheads reside in areas where surface waters converge to form local down-wellings. Post-hatchlings are observed to be low-energy float-and-wait foragers that feed on a wide variety of floating items. As post-hatchlings, loggerheads may linger for months in waters near the nesting beach or become transported by ocean currents within the Gulf of Mexico and North Atlantic. Somewhere between 7-12 years old, oceanic juveniles migrate back to nearshore coastal areas, foraging on clams, whelks and conch (NOAA 2017).

Listed turtles occurring in Virginia estuarine/marine waters broadly rely on benthic invertebrates, including mussels, crustaceans, and plants as primary food sources, all of which are relatively insensitive to acute and chronic cadmium exposures in freshwaters. In estuarine/marine water, the most sensitive species to acute cadmium exposures (and by extension, chronic cadmium exposure given limited chronic estuarine/marine data) include two mysid genera (*Neomysis* and *Americamysis*), a copepod (*Tigriopus*), and a jellyfish (*Aurelia*). Remaining acute estuarine/marine cadmium toxicity data indicate sea turtle prey items, bivalves, plants, crustaceans, and other invertebrates, are insensitive to acute and chronic cadmium exposures in marine/estuarine environments (Table 10 of USEPA 2016).

Jellyfish rank among the most sensitive genera to acute cadmium exposures in estuarine/marine waters and serve as valuable prey for leatherback turtles; however, aquatic life criteria are based on the fifth centile of sensitive genera and are derived to protect aquatic communities, including jellyfish. For example, members of the genus *Aurelia*, and potentially other members of the order Semaeostomeae, may be sensitive to cadmium exposures in estuarine/marine waters relative to other genera, but are not appreciably sensitive relative to the acute estuarine criterion itself because the *Aurelia* GMAV (61.75 µg/L total cadmium) is nearly two times greater than the estuarine CMC of 33.13 µg/L total cadmium. Similarly, NOAA fisheries (NMFS 2012) previously assessed the protectiveness of earlier, less stringent, cadmium criteria (USEPA 2001; CMC = 40.28 µg/L; CCC = 8.9 µg/L; hardness = 100 mg/L) on leatherback turtle critical habitat in Oregon and concluded:

> "*The PCEs that NMFS identified as essential for the conservation of leatherback sea turtles…(1) A sufficient quantity and quality of their jellyfish prey…Based on the best scientific and commercial data available, as discussed previously, NMFS does not expect that the proposed action would adversely affect the quantity,*

quality, or availability of any of the constituent elements of critical habitat, or the physical, chemical, or biotic phenomena that give the designated area value for the conservation of the species…"

Sea turtle food resources will not be measurably affected by cadmium at criteria magnitudes and durations associated with the acute and chronic estuarine/marine criteria (USEPA 2016). Further, sea turtles are migratory species and generalist feeders, relying on a range of food resources, both within and outside of the action area, which mitigates any resultants effects of limiting a large portion of a single food resource (which is not the expected outcome of the action). As a result, the effects of the approval of the acute and chronic estuarine/marine cadmium criteria the green sea turtle, leatherback turtle, hawksbill turtle, Kemp's ridley turtle, and loggerhead turtle are too small to be detected, and therefore insignificant.

3.3 Whales: Finback (*Balaenoptera physalus*) and North Atlantic Right (*Eubalaena glacialis*)

3.3.1 Whale Acute and Chronic Cadmium Effects Assessment: Estuarine/Marine

Whales will experience no effects associated with approval to the freshwater acute and chronic cadmium criteria due to no expected co-occurrence of whales and cadmium in Virginia freshwaters. Given the immense dilution associated with marine environments, co-occurrence of whales and cadmium at exposure concentrations and durations associated with the acute and chronic estuarine/marine criteria is also unlikely. For example, NOAA fisheries (NMFS 2012) previously assessed the protectiveness of earlier, less stringent, cadmium criteria (USEPA 2001; CMC = 40.28 µg/L; CCC = 8.9 µg/L; hardness = 100 mg/L) for estuarine/marine waters in Oregon and concluded:

> "*In this opinion NMFS concludes that the proposed action is not likely to adversely affect (NLAA) Steller sea lions, humpback whales, blue whales, fin whales, Sei whales, sperm whales, North Pacific Right whales…The above identified marine mammal and sea turtle species are distributed in coastal areas and may be exposed to effects related to the proposed numeric criteria. Similar to Southern Resident killer whales, effects would be indirect and would include reduced prey availability, reduced prey quality, and potential accumulation in the individuals exposed. However, the occurrence of the subject ESA-listed sea turtles and large whales would be rare, infrequent, and transitory in the action area. For example, the blue whale and Sei whale are likely to have limited exposure to contaminant sources as their migratory patterns are circumglobal with definite seasonal movements to offshore areas outside the likely extent of effects.*"

The finback whale is unlikely to be exposed to cadmium, or other pollutants, at acute or chronic criterion magnitudes (USEPA 2016) because fin whales are primarily found in deep water, rather than near-shore habitat, significantly reducing exposure potential. Similarly, NOAA Fisheries (NOAA 2017) cited the same rationale to concur finback whales are not likely to be adversely affected by three pesticide contaminants, stating:

Direct effects to listed cetaceans from the action are not expected due to dilution of the three a.i.s (i.e., diazanon, chlorpyrifos, or malathion) *in the marine environments (resulting in a very low potential for exposure) and the cetaceans' very large size (very low potential for effects). Additionally, some of the listed cetaceans are found primarily in deep, ocean waters [i.e., Sei whale (Balaenoptera borealis), Bryde's whale (Balaenoptera edemi), blue whale (Balaenoptera musculus), fin whale (Balaenoptera physalus), humpback whale (Megaptera novaeangliae), and sperm whale (Physeter microcephalus (=icrocephalus)], and/or are circumpolar [i.e., the bowhead whale (Balaena mysticetus)]. Species that are found primarily in deep waters or are circumpolar (i.e., found at high latitudes around the earth's Polar Regions) are expected to range far from any potential application sites – further limiting the potential for exposure.*

While the North Atlantic right whale relies on coastal waters more than the fin whale, exposure potential to cadmium remains negligible, especially because the North Atlantic right whale primarily uses Virginia estuarine/marine waters for migration purposes, as they travel between calving grounds south of Cape Fear, NC, to wintering grounds off of the New England coast (NOAA Fisheries, Species Directory: www.fisheries.noaa.gov/species/north-atlantic-right-whale; Accessed 7/12/2018). Given limited exposure potential and relatively large sizes (limiting potential effects), effects of the approval of the acute and chronic estuarine/marine cadmium criteria to the finback whale or North Atlantic right whale are extremely unlikely to occur and therefore discountable.

3.3.2 Whale Cadmium Indirect Effects Assessment: Freshwater and Estuarine/Marine

North Atlantic right whales consume zooplankton and copepods, filtering pelagic organisms from the water column through their baleen (NOAA Fisheries, Species Directory: www.fisheries.noaa.gov/species/north-atlantic-right-whale; Accessed 7/12/2018), while finback whales consume krill, herring, sand lance, capelin, and squid (NOAA Fisheries, Species Directory: www.fisheries.noaa.gov/species/fin-whale; Accessed 7/12/2018). Finback whale range is circum-global and the North Atlantic right whale tend to occupy Virginia marine waters only during migration, providing extensive food resources outside of pelagic organisms occurring in near-shore habitats within the action area. Given available food resources outside of near-shore habitats within Virginia and because aquatic life criteria are based on the 5^{th} centile of sensitive genera to ensure aquatic communities, including whale dietary resources, are protected from acute and chronic cadmium exposures, effects of cadmium exposure to whale prey items within Virginia will be negligible and would insignificantly translate to dietary resources as a whole. For example, NOAA Fisheries (NOAA 2017) cited similar considerations to determine the finback and North Atlantic right whales are not likely to be adversely affected through indirect effects by three pesticides contaminants, stating:

For indirect effects (i.e., reductions in whales' prey), due to the effect of dilution in the types of marine environments in which the listed cetaceans are found and distance from potential use sites, risks from the potential loss of marine *invertebrate and vertebrate prey are not expected. Therefore, for the listed cetaceans that rely wholly on marine prey [i.e.,…fin*(back) *whale, North Atlantic right whale…), we do not expect indirect effects from the potential loss of prey. For these species, we consider the risk for indirect effects to be low (due to limited exposure) and we have high confidence in this risk assessment.*

Given minimal anticipated effects to whale prey items within and outside of the action area, the effects of approval of the acute and chronic estuarine/marine cadmium criteria to the finback whale or North Atlantic right whale are extremely unlikely to occur and therefore discountable.

4 Conclusion: Final Effects Determinations

Listed sturgeon, turtles, and whales occurring in Virginia freshwaters and/or estuarine/marine waters are insensitive to acute and chronic freshwater ammonia and cadmium exposures at the respective criteria magnitudes under conservative exposure conditions. Further, aquatic life criteria are implemented conservatively and are based on the fifth centile of sensitive genera to ensure aquatic communities, including listed species prey items, are adequately protected. As a result, the indirect or direct effects of approval of the acute and chronic ammonia (freshwater) and cadmium (freshwater and estuarine/marine) criteria as Virginia state water quality standards are insignificant and/or discountable and the action is Not Likely to Adversely Affect (NLAA) these species (Table 4-1).

Table 4-1. Final effect determinations for aquatic listed species occurring in Virginia that may be affected by the approval action. Final effects determinations for listed species are based on direct and indirect effects.

Species	Final Effects Determination
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)	***NLAA*** (direct and indirect effects)
Shortnose Sturgeon (*Acipenser brevirostrum*)	***NLAA*** (direct and indirect effects)
Green Sea Turtle (*Chelonia mydas*)	***NLAA*** (direct and indirect effects)
Leatherback Turtle (*Dermochelys coriacea*)	***NLAA*** (direct and indirect effects)
Kemp's Ridley Turtle (*Lepidochelys kempii*)	***NLAA*** (direct and indirect effects)
Loggerhead Turtle (*Caretta caretta*)	***NLAA*** (direct and indirect effects)
Finback Whale (Balaenoptera physalus)	***NLAA*** (direct and indirect effects)
North Atlantic Right (*Eubalaena glacialis*)	***NLAA*** (direct and indirect effects)

5 Critical Habitat: Effects Assessment and Final Critical Habitat Effects Determinations

5.1 Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) Critical Habitat

Critical habitat for the Atlantic sturgeon Chesapeake Bay distinct population segment was designated in 2017 and encompasses lower reaches of several Virginia Rivers, including the Potomac, Rappahannock, York, Mattaponi, and Pamunkey Rivers (NOAA 2015). NOAA identifies a key objective for the Chesapeake Bay DPS is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. The Physical or biological features (PBFs) that require special management considerations concerning any proposed action in the proposed critical habitat for the Atlantic sturgeon are discussed below. PBFs considered present within this action area are outlined below.

PBF 1: Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;

The revisions to the ammonia and cadmium criteria focus solely on the allowable levels of those pollutants throughout the action area. Waters with ammonia and/or cadmium at or under the magnitude of the criteria would have no effect on actual hard bottom substrate, nor would they shift salinity levels in waters of the action area that may possess this PBF. Therefore, there would also be no effects of the criteria on the settlement of fertilized eggs, refuge, growth, and development of early life stages.

PBF 2: Aquatic habitat with a gradual downstream salinity gradient of 0.5-30 parts per thousand and soft substrate (e.g., sand, mud) downstream of spawning sites for juvenile foraging and physiological development;

The revisions to the ammonia and cadmium criteria focus solely on the allowable levels of those pollutants throughout the action area. Because of the tendency for cadmium to bind readily with soft sediments, cadmium may be bioavailable to benthic feeders such as sturgeon, and it may become a part of the actual physical feature (soft sediment within a downstream salinity gradient of 0.5 to 30 parts per thousand) protected under PBF 2. However, any effects are extremely unlikely to occur because the cadmium criteria is set below levels that could potentially affect juvenile and foraging Atlantic sturgeon. As such any effects to the value of this PBF to the conservation of the species is discountable.

PBF 3: Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) unimpeded movements of adults to and from spawning sites; (2) seasonal and physiologically-dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; (3) staging, resting, or holding of subadults or spawning condition adults. Water depths in the main river channels must also be deep enough (e.g., ≥1.2 m) to ensure continuous *flow in the main channel at all times when any sturgeon life stage would be in the river, and;*

The revisions to the ammonia and cadmium criteria focus solely on the allowable levels of those pollutants throughout VA waters. The effects of the criteria on appropriate water depth and physical barriers to passage to support unimpeded movement of adults to and from spawning sites, seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary and staging, and resting or holding of subadults or spawning condition adults are extremely unlikely to occur. Because the water quality criteria have been set at a level that is not likely to adversely affect the listed species, any waters with ammonia or cadmium at or below the criteria magnitude would be below levels detectable by sturgeon and as such any effects to the value of the PBF to the conservation of the species would be extremely unlikely to occur and discountable.

PBF 4: Water, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (1) spawning; (2) annual and inter-annual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment (e.g., 13° C to 26° C for spawning habitat and no more than 30° C for juvenile rearing habitat, and 6 mg/L dissolved oxygen for juvenile rearing habitat).

The revisions to the ammonia and cadmium criteria focus solely on the allowable levels of those pollutants throughout VA waters. Waters with ammonia and/or cadmium at or under the magnitude of the criteria would have no effect on temperature, salinity, and oxygen values between the river mouth and spawning sites, especially in the bottom meter of the water column, that, combined, support spawning, annual and interannual adult, subadult, larval and juvenile survival; larval, juvenile and subadult growth, development and recruitment.

To determine whether EPA's approval of VA's water quality criteria for ammonia and cadmium is likely to adversely affect critical habitat, EPA evaluated the effects of ammonia and cadmium relative to the essential features of habitat. In evaluating the effects of the action on critical habitat, EPA concluded that the essential features of the critical habitat relate to physical structures of the river such as water depth, substrate composition, barriers to passage, water velocity, instream cover, etc. as well as dissolved oxygen and salinity, will not be adversely affected by the ammonia and cadmium criteria approval. There are no effects of the proposed action on PBFs 1 and 4; while the effects of the proposed criteria on PBF 3 and PBF 4 are extremely unlikely to occur and discountable. Additionally, the proposed criteria will not affect the sound, habitat structure and disturbance, dredging, water quality (turbidity), in-water structures, prey quality/quantity, or vessel traffic for any of the listed species. As such, the action is not likely to adversely affect critical habitat for Atlantic sturgeon.

6 Conclusion

EPA views the ammonia and cadmium criteria revisions as insignificant and/or discountable to the conservation and protection of aquatic life, including listed species and their food sources in Virginia. EPA recognizes the need to revise its decision if this consultation identifies situations where the criteria may not be adequately protective of listed species populations. If this should be the case, EPA will coordinate with NMFS to determine a reasonable approach.

7 References[3]

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September 17, 2018

GARFO Species List

(Proceed to page 2 for complete reference list)

Whales:

North Atlantic right whale (*Eubalaena glacialis*)(73 FR 12024; Recovery plan: NMFS 2005)
Fin whale (*Balaenoptera physalus*)(35 FR 18319; Recovery plan: NMFS 2010a)
Sei whale (*Balaenoptera borealis*)(35 FR 18319; Recovery plan: NMFS 2011)
Sperm whale (*Physeter macrocephalus*)(35 FR 18319; Recovery plan: NMFS 2010b)
Blue whale (*Balaenoptera musculus*)(35 FR 18319; Recovery plan: NMFS 1998b)

Sea Turtles:

Loggerhead turtle (*Caretta caretta*)(76 FR 58868; Recovery plan: NMFS & USFWS 2008) [4]
Leatherback turtle (*Dermochelys coriacea*)(35 FR 8491; Recovery plan: NMFS & USFWS 1992a)
Green turtle (*Chelonia mydas*)(81 FR 20057; Recovery plan: NMFS & USFWS 1991) [5]
Kemp's ridley turtle (*Lepidochelys kempii*)(35 FR 18319; Recovery plan: NMFS *et al.* 2011)
Hawksbill turtle (*Eretmochelys imbricata*)(35 FR 8491; Recovery plan: NMFS & USFWS 1992b)

Fish:

Shortnose sturgeon (*Acipenser brevirostrum*)(32 FR 4001; Recovery plan: NMFS 1998a)
Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)(77 FR 5880 and 77 FR 5914)[6]
Atlantic salmon (*Salmo salar*)(74 FR 29344; Recovery plan: NMFS & USFWS 2005)[7]

Critical Habitat:

North Atlantic right whale (81 FR 4837)
Loggerhead turtle (79 FR 4837)
Atlantic sturgeon (82 FR 39160)
Atlantic salmon (74 FR 29300)

ESA Listing Rules:

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[4] For loggerhead turtles, only the Northwest Atlantic Distinct Population Segment (DPS) occurs in the Greater Atlantic Region

[5] For green turtles, only the North Atlantic DPS occurs in the Greater Atlantic Region

[6] For Atlantic sturgeon, there are five listed DPSs that may occur in the Greater Atlantic Region: (1) Gulf of Maine, (2) New York Bight, (3) Chesapeake Bay, (4) Carolina, and (5) South Atlantic

[7] For Atlantic salmon, there is one listed DPS: the Gulf of Maine DPS

North Atlantic right whale:
(73 FR 12024; March 6, 2008)

Fin, Sei, Sperm, and Blue whales:
(35 FR 18319; December 2, 1970)

Loggerhead turtle:
(76 FR 58868; September 20, 2011)

Leatherback turtle:
(35 FR 8491; June 2, 1970)

Green turtle:
(81 FR 20057; April 6, 2016)

Kemp's ridley and Hawksbill turtles:
(35 FR 18319; December 2, 1970)

Shortnose sturgeon:
(32 FR 4001; March 8, 1967)

Atlantic sturgeon:
(77 FR 5880; February 6, 2012)

(77 FR 5914; February 6, 2012)

Atlantic salmon:
(74 FR 29344; June 19, 2009) ***Species Recovery Plans:***

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Attachment 1

Species Listed Under the Endangered Species Act Under the Jurisdiction of NMFS' Greater Atlantic Region (MAINE through VIRGINIA). https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/gar_sp_present_table_mar172016.pdf. Accessed on 10/10/2018.

SPECIES LISTED UNDER THE ENDANGERED SPECIES ACT UNDER THE JURISDICTION OF NMFS's GREATER ATLANTIC REGION (MAINE - VIRGINIA)

For a list of Candidate Species in the Greater Atlantic Region (GAR), please visit https://www.greateratlantic.fisheries.noaa.gov/protected/pcp/cs/index.html
For a list of Species of Concern in the GAR, please visit https://www.greateratlantic.fisheries.noaa.gov/protected/pcp/soc/index.html

FISH

Atlantic Salmon (*Salmo salar*) (Gulf of Maine DPS)

Year listed: 2000; More recent listing for Gulf of Maine Atlantic salmon as a Distinct Population Segment (DPS) encompassing a wider range in the state of Maine in 2009; Atlantic salmon are listed jointly with U.S. Fish and Wildlife Service.
Status: Endangered
General distribution: The distribution of endangered Atlantic salmon extends from the Androscoggin River in South Western Maine to the Dennys River in Eastern Maine.
Critical habitat in GAR: Critical habitat for Atlantic salmon was designated in 2009. Forty-five specific areas containing over 19,000 kilometers of rivers and streams and 799 square kilometers of lakes and ponds were identified as having the physical and biological features essential to the conservation of the species, which may require special management or protections. For more information, please visit the map book at https://www.greateratlantic.fisheries.noaa.gov/protected/atlsalmon/ **Additional Information**: For additional distribution information, select references, and other relevant information, please visit https://www.greateratlantic.fisheries.noaa.gov/protected/atlsalmon/ and http://www.fisheries.noaa.gov/pr/species/fish/atlantic-salmon.html

Shortnose Sturgeon (*Acipenser brevirostrum*)

Year listed: 1967
Status: Endangered
General distribution: Shortnose sturgeon occur in marine and estuarine habitat, including freshwater reaches of large rivers with access to the sea, which extends from the Minas Basin, Nova Scotia to the St. Johns River, Florida. There have been documented coastal movements between some of the major rivers.
Critical habitat in GAR: None
Additional Information: For additional distribution information, select references, and other relevant information, please visit https://www.greateratlantic.fisheries.noaa.gov/protected/snsturgeon/index.html and http://www.nmfs.noaa.gov/pr/species/fish/shortnose-sturgeon.html

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

Year listed: 2012 (Effective April 6, 2012)
Status: Five Distinct Population Segments (DPSs) designated along the U.S. East Coast. The Gulf of Maine population is listed as threatened while the New York Bight, Chesapeake Bay, Carolina, and South Atlantic populations are listed as endangered.
General distribution: Atlantic sturgeon belonging to each of the five DPSs occur in marine and estuarine habitat, including freshwater reaches of large rivers with access to the sea, from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, U.S. The range of all five DPSs overlap.
Critical habitat in the GAR: In select rivers from Maine through Virginia; Please visit: http://sero.nmfs.noaa.gov/protected_resources/sturgeon/documents/critical_habitat_maps.pdf
Additional Information: For additional distribution information, select references, and other relevant information, please visit https://www.greateratlantic.fisheries.noaa.gov/protected/atlsturgeon/index.html and http://www.fisheries.noaa.gov/pr/species/fish/atlantic-sturgeon.html

MARINE MAMMALS

Blue Whale (*Balaenoptera musculus musculus*)

Year listed: 1970
Status: Endangered
General distribution: The distribution of the blue whale in the western North Atlantic generally extends from the Arctic to at least mid-latitude waters. The blue whale is best considered as an occasional visitor in U.S. Atlantic Exclusive Economic Zone (EEZ) waters, which may represent the current southern limit of its feeding range (CETAP 1982; Wenzel et al. 1988). The actual southern limit of the species' range is unknown.
Critical habitat in GAR: None
Additional Information: For additional distribution information, select references, and other relevant information, please visit http://www.fisheries.noaa.gov/pr/species/mammals/whales/blue-whale.html and http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2010whbl-wn.pdf

Fin Whale (*Balaenoptera physalus*)

Year listed: 1970
Status: Endangered
General distribution: Fin whales are common in waters of the U. S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward. Fin whales are migratory, moving seasonally into and out of high-latitude feeding areas, but the overall migration pattern is complex, and specific routes have not been documented. However, acoustic recordings from passive-listening hydrophone arrays indicate that a southward "flow pattern" occurs in the fall from the Labrador-Newfoundland region, past Bermuda, and into the West Indies (Clark 1995).
Critical habitat in GAR: None
Additional Information: For additional distribution information, select references, and other relevant information, please visit http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/finwhale.htm and http://www.nmfs.noaa.gov/pr/sars/pdf/stocks/atlantic/2015/f2015_finwhale.pdf

North Atlantic Right Whale (Eubalaena glacialis)

Year listed: 1970; Listed as two separate, endangered species in 2008 - the North Pacific right whale (Eubalaena japonica) and North Atlantic right whale (Eubalaena glacialis)
Status: Endangered
General distribution: Population ranges primarily from calving grounds in coastal waters of the southeastern United States to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence.
Critical habitat in GAR: Expanded to include the Gulf of Maine and Georges Bank. Please see: http://www.fisheries.noaa.gov/pr/species/critical%20habitat%20files/ne_narw_ch.pdf **Additional Information:** For additional distribution information, select references, and other relevant information, please visit http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rightwhale_northatlantic.htm and http://www.nmfs.noaa.gov/pr/sars/pdf/stocks/atlantic/2015/f2015_rightwhale.pdf

Sei Whale (Balaenoptera borealis)

Year listed: 1970
Status: Endangered
General distribution: The range of the Nova Scotia stock includes the continental shelf waters of the northeastern U.S., and extends northeastward to south of Newfoundland. Indications are that, at least during the feeding season, a major portion of the Nova Scotia sei whale stock is centered in northerly waters, perhaps on the Scotian Shelf (Mitchell and Chapman 1977). The southern portion of the species' range during spring and summer includes the northern portions of the U.S. Atlantic Exclusive Economic Zone (EEZ) — the Gulf of Maine and Georges Bank. Spring is the period of greatest abundance in U.S. waters, with sightings concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (CETAP 1982).
Critical habitat in GAR: None
Additional Information: For additional distribution information, select references, and other relevant information, please visit http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/seiwhale.htm and http://www.nmfs.noaa.gov/pr/sars/pdf/stocks/atlantic/2015/f2015_seiwhale.pdf

Sperm Whale (Physeter macrocephalus)

Year listed: 1970
Status: Endangered
General distribution: Sperm whales feed on larger organisms that inhabit the deeper ocean regions (Whitehead 2002). Calving for the species occurs in low latitude waters. The distribution of the sperm whale in the U.S. Exclusive Economic Zone (EEZ) occurs primarily on the continental shelf edge, over the continental slope, and into mid-ocean regions.
Critical habitat in GAR: None
Additional Information: For additional distribution information, select references, and other relevant information, please visit http://www.fisheries.noaa.gov/pr/species/mammals/whales/sperm-whale.html and http://nefsc.noaa.gov/publications/tm/tm231/63_spermwhale_F2014July.pdf

SEA TURTLES

While sea turtles occur year-round off the southeastern United States, they are generally present in marine and estuarine waters of the GAR from April through November. As water temperatures warm in the spring, sea turtles begin to migrate to nearshore waters and up the U.S. Atlantic coast, occurring in Virginia as early as April/May and in the Gulf of Maine in June. The trend is reversed in the fall with some animals remaining in the GAR until late fall. Outside of these times, sea turtle presence in GAR waters is considered unlikely, although juvenile sea turtles routinely strand on GAR beaches during colder months (i.e., from October to January) as a result of cold-stunning. Nesting is extremely limited in the GAR. Typically, juveniles and, to a lesser extent, adults are present in the GAR. Sea turtles are listed jointly with U.S. Fish and Wildlife Service. For additional distribution information, select references, and other relevant information, please visit https://www greateratlantic.fisheries.noaa.gov/protected/seaturtles/index.html and http://www.nmfs.noaa gov/pr/species/turtles/

Green Sea Turtle (Chelonia mydas)

Year listed: 1978; Eleven Distinct Population Segments (DPSs) designated in 2016
Status: The Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific DPSs are listed as threatened. The Central South Pacific, Central West Pacific, and Mediterranean DPSs are listed as endangered. Only the North Atlantic DPS is present in the GAR.
General Distribution: In the U.S. Atlantic, green turtles are occasionally found as far north as New England, but are more commonly seen from New York south. They occur seasonally in GAR waters, including but not limited to the Chesapeake Bay and Long Island Sound, which serve as foraging and developmental habitats.
Critical habitat in GAR: None
Additional Information: http://www.nmfs.noaa.gov/pr/species/turtles/green.html

Hawksbill Turtle (Eretmochelys imbricata)

Year listed: 1970
Status: Endangered
General Distribution: Hawksbill turtles are circumtropical. In the U.S. Atlantic, they are found primarily in Florida and Texas, though they have been recorded along the east coast as far north as Massachusetts. Hawksbills are rare visitors to the waters of the GAR.
Critical habitat in GAR: None
Additional Information: http://www.nmfs.noaa.gov/pr/species/turtles/hawksbill.html

Kemp's Ridley Turtle (Lepidochelys kempii)

Year listed: 1970

Status: Endangered **General Distribution:** Kemp's ridleys typically occur only in the Gulf of Mexico and the northwestern Atlantic. In the U.S. Atlantic, they are found as far north as New England seasonally. Foraging areas in the GAR include, but are not limited to, Chesapeake Bay, Delaware Bay, Cape Cod Bay, and Long Island Sound.

Critical habitat in GAR: None

Additional Information: http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.html

Leatherback Turtle (*Dermochelys coriacea*)

Year listed: 1970

Status: Endangered

General Distribution: Leatherback sea turtles are globally distributed. They range farther than any other sea turtle species. Although frequently thought of as an oceanic species, they are also known to use coastal waters of the U.S. continental shelf. Juveniles and adults are present in the GAR seasonally and are distributed as far north as Canada.

Critical habitat in GAR: None

Additional Information: http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.html

Loggerhead Turtle (*Caretta caretta*)

Year listed: 1978; Nine Distinct Population Segments (DPSs) designated in 2011

Status: The Northwest Atlantic, South Atlantic, Southeast Indo-Pacific, and Southwest Indian Ocean DPSs are listed as threatened. The Northeast Atlantic, Mediterranean, North Indian, North Pacific, and South Pacific Ocean DPSs are listed as endangered. Only the Northwest Atlantic DPS is present in the GAR.

General Distribution: Loggerheads, the most abundant species of sea turtle in U.S. waters, have a temperate and subtropical distribution, including offshore waters, continental shelves, bays, estuaries, and lagoons. In the U.S. Atlantic, their range extends north to southern Canada. They most commonly occur throughout the inner continental shelf from Florida to Massachusetts. As with other sea turtle species, their presence in the GAR varies seasonally.

Critical habitat in GAR: Sargassum critical habitat in offshore waters associated with the Gulf Stream current off Maryland and Virginia.

Additional Information: http://www.nmfs.noaa gov/pr/species/turtles/loggerhead.html and http://www.nmfs.noaa.gov/pr/species/turtles/criticalhabitat_loggerhead.htm